SAS Performance Analytics Library

July 16, 2015

**Type** Package

**Title** Econometric tools for performance and risk analysis

**Version** 1.01

**Description**

A collection of econometric functions for performance and risk analysis. This library aims to aid practitioners and researchers in utilizing research in analysis of return streams. In general, it is most tested on returns (rather than price) data on a regular scale, but most functions will work with irregular return data as well. This package aims to replicate the Performance Analytics package available in R with a few minor tweaks to improve functionality, but otherwise adhering very closely to R Performance Analytics.

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**Authors** Dominic Pazzula

Carter Johnston

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# SAS topics documented:

[ActivePremium……………………………………………………………………………………………………………………………6](#name_activePremium)

[Adjusted\_SharpeRatio…………………………………………………………………………………………………………………7](#name_Adjusted_SharpeRatio)

[Appraisal\_Ratio…………………………………………………………………………………………………………………………..8](#name_appraisalRatio)

[BetaCoMoments…………………………………………………………………………………………………………….…………10](#name_BetaCo)

[CAPM\_alpha\_beta…………………………………………………………………………………………………………….………11](#name_CAPMalphabeta)

[CAPM\_epsilon………………………………………………………………………………………………………………….……….12](#name_CAPMepsilon)

[CAPM\_JensenAlpha………………………………………………………………………………………………………………….14](#name_CAPMJensenalpha)

[Centered\_moments………………………………………………………………………………………………………………….15](#name_CenteredMoments)

[Chart\_Histogram……………………………………………………………………………………………………………………….16](#name_ChartHistogram)

[Chart\_Correlation…………………………………………………………………………………………………………………….17](#ChartCorrelation_TOC)

[CoMoments………………………………………………………………………………………………………………………………19](#name_CoMoments)

[Fama\_Beta………………………………………………………………………………………………………………………………..20](#name_famabeta)

[Geo\_Mean………………………………………………………………………………………………………………………………..21](#name_GeoMean)

[Information\_Ratio…………………………………………………………………………………………………………………….22](#name_InformationRatio)

[MSquared…………………………………………………………………………………………………………………………………24](#name_MSquared)

[Prices………………………………………………………………………………………………………………………………………..25](#name_prices)

[Return\_Annualized……………………………………………………………………………………………………………………25](#name_Return_Annualized)

[Return\_Calculate………………………………………………………………………………………………………………………27](#name_Return_Calculate)

[Return\_Centered……………………………………………………………………………………………………………………...28](#name_Return_Centered)

[Return\_Cumulative…………………………………………………………………………………………………………………..29](#name_Return_Cumulative)

[Return\_Excess……………………………………………………………………………………………………………………….….30](#name_Return_Excess)

[Sharpe\_Ratio………………………………………………………………………………………………………………………..…..32](#name_SharpeRAtio)

[SharpeRatio\_Annualized………………………………………………………………………………………………………..…33](#name_SharpeRatioAnnualized)

[Specific\_Risk……………………………………………………………………………………………………………………………..34](#name_SpecificRisk)

[Standard\_Deviation…………………………………………………………………………………………………………………..36](#name_StandardDeviation)

[StdDev\_Annualized………………………………………………………………………………………………………………..…37](#name_StdDevAnnualized)

[Systematic\_Risk………………………………………………………………………………………………………………..………38](#name_SystematicRisk)

[Table\_Annualized\_Returns…………………………………………………………………………………………..………….40](#name_tableAnnualizedReturns)

[Table\_AutoCorrelations…………………………………………………………………………..……………………….………41](#name_tableAutoCorrelations)

[Table\_CalendarReturns…………………………………………………………………………………………………….………42](#name_tableCalendarReturns)

[Table\_Correlation………………………………………………………………………………………………………………..……43](#name_tableCorrelations)

[Table\_Distributions……………………………………………………………………………………………………………..……44](#name_tableDistributions)

[Table\_HigherMoments……………………………………………………………………………………………………….…….45](#name_tableHigherMoments)

[Table\_InformationRatio……………………………………………………………………………………………………………46](#name_tableInformationRatio)

[Table\_SpecificRisk…………………………………………………………………………………………………………………….47](#name_tableSpecificRisk)

[Table\_Stats…………………………………………………………………………………………………………………………….…48](#name_tableStats)

[Table\_Variability…………………………………………………………………………………………………………………….…49](#name_tableVariability)

[TrackingError…………………………………………………………………………………………………………………….………50](#name_trackingError)

**SAS Performance Analytics Library**

Econometric tools for performance and risk analysis.

**Description**

Working for the Financial Risk Group, the creators of the SAS Performance Analytics macro library saw an opportunity: to recreate the performance analytics package found in R in SAS to implement performance analysis tools needed for the FRG platform. Performance Analytics provides a SAS package of econometric functions for performance and risk analysis of financial instruments or portfolios. This packages aims to aid practitioners and researchers in using the latest research for analysis of a returns series.

We created this library to include functionality that appears in the R Performance Analytics package, which is taken from academic literature on performance analysis and risk. These tools had no functional equivalent in SAS previously. Generally, this package requires return data rather than price data. However, price data can be quickly converted to returns data with the use of the macro [Return\_Calculate](#name_Return_Calculate). Almost all of the macros in this library will work with annual, quarterly, monthly, or daily frequency. In the following summary, we attempt to provide an overview of the capabilities provided by SAS Performance Analytics. We hope that the accompanying library and documentation can fill the void when it comes to financial risk and performance analytics tools available to an analyst using the SAS system.

With the growing accessibility to alternative assets to the individual investor, demand has become ever higher for research and analysis tools in performance analytics. The simple tools that were appropriate in a relative investment world now seem inappropriate for investment returns in the current context. Risk measurement, which is inseparable from performance assessment, has become multi-dimensional and multi-moment all the while attempting to answer a very simple question: “What is my risk?” Portfolio construction and risk budgeting are then two sides of the same coin: optimizing a portfolio by maximizing return while minimizing volatility. With the increasing availability of complicated alternative investment strategies to investors, and the state of near perfect information, an engaging debate about performance analysis and evaluation is as crucial as ever.

Performance analytics does not guarantee a perfect portfolio immune to all risk. However, what it does offer is an accretion of evidence, organized to assist a decision maker in answering a specific question on a particular asset or portfolio. Using such tools to uncover information and ask better questions will create a better informed investor. Performance measurement starts with returns. However, the normalization inherent in calculating returns can be deceiving. It is important that returns be standardized because this “price per unit of investment” standardization is useful in comparing opportunity costs and because of the standardization’s useful statistical qualities. As a result, the Performance Analytics library focuses on standardized returns rather than prices [See [Return\_calculate](#name_Return_Calculate) for converting net asset values or prices into returns, either discrete or log based]. Many papers and theories refer to “excess returns”, or risk premium: we implement a simple function for aligning time series and calculating these excess returns in [Return\_excess](#name_Return_Excess). Returns and risk may be annualized as a way to simplify comparison over longer or unequal time periods. Although it requires a bit of estimating, such aggregation is popular because it offers a reference point for easy comparison. Examples of this estimation can be found in [Return\_annualized](#name_Return_Annualized), [StdDev\_annualized](#name_StdDevAnnualized), and [SharpeRatio\_annualized](#name_SharpeRatioAnnualized). Basic measures of performance tend to treat returns as independent observations. In this case, the entirety of the SAS base is applicable to such analysis. Some basic statistics are collected in [table.Stats](#name_tableStats).

These types of summary statistics and tables provide the bulk of the information an investor may want to analyze, and provides an organized way to view results of potentially thousands of periodic return data. Usually these statistics are the most “readable” when organized into a table of related statistics assembled for a particular purpose. A common offering of past returns organized by month and cumulated by calendar year is usually presented as a table, such as in [table\_CalendarReturns](#name_tableCalendarReturns). Adding benchmarks or peers alongside the annualized data is helpful for comparing returns in calendar years. Examples of other tables for comparison of related groupings of statistics discussed in this documentation:

[table.Stats](#name_tableStats) provides Basic statistics and stylized facts

[table.AnnualizedReturns](#name_tableAnnualizedReturns) Annualized return, standard deviation, and Sharpe ratio [table.CalendarReturns](#name_tableCalendarReturns) Monthly and calendar year return table

[table.Correlation](#name_tableCorrelations) Comparison of correlations and significance statistics

[table.Autocorrelation](#name_tableAutoCorrelations) The first six autocorrelation coefficients and significance [table.HigherMoments](#name_tableHigherMoments) Higher co-moments and beta co-moments

[table\_Distributions](#name_tableDistributions) provides distribution statistics

[table\_InformationRatio](#name_tableInformationRatio) Provides the information ratio as well as the tracking error and annualized tracking error.

[table\_SpecificRisk](#name_tableSpecificRisk) Table of specific risk, systematic risk, and total risk.

[table\_Variability](#name_tableVariability) Table of variability statistics from a returns data set.

Modern Portfolio Theory (MPT), although somewhat ironically outdated, is the collection of tools and techniques by which a risk-averse investor may construct an “optimal” portfolio. It was pioneered by Harry Markowitz in 1952 and encompasses CAPM, the efficient market hypothesis, and all forms of quantitative portfolio construction and optimization. The Capital Asset Pricing Model (CAPM), initially developed by William Sharpe in 1964, provides a justification for passive or index investing by proposing that assets that are not on the efficient frontier will either rise or fall in price until they are. The [CAPM­ alpha](#name_CAPMalphabeta) is the degree to which the asset’s returns are not due to the return that could be captured from the market as a whole. Conversely, the [CAPM beta](#name_CAPMalphabeta) describes the portions of the returns of the asset that could be directly attributed to the returns of a passive investment in the benchmark asset. CAPM is a market equilibrium model or a general equilibrium theory of the relation of prices to risk, but it is usually applied to partial equilibrium portfolios, which can create (sometimes serious) problems in valuation. The performance premium provided by an investment over a passive strategy (the benchmark) is provided by the [active premium](#name_activePremium), which is the investment’s annualized return minus the benchmark’s annualized return. A closely related measure is the [Tracking Error](#name_trackingError), which measures the unexplained portion of the investment’s performance relative to a benchmark. The [Information Ratio](#name_InformationRatio) of an investment in a MPT or CAPM framework is the Active Premium divided by the Tracking Error. The Information Ratio may be used to rank investments in a relative fashion. Research shows that relative rankings across multiple pricing methodologies may be positively correlated with each other and with expected returns. This is quite an important finding because it shows that multiple methods of predicting returns and risk which have underlying measures and factors which are not directly correlated to another measure or factor will still producesimilar quantile rankings. While analyzing an asset or portfolio using the performance analytics tools in this library does not guarantee greater returns, verifying the asset or portfolio over multiple measures for evidence will help prove a positive investment decision for the rational investor.

While we acknowledge that the library is currently incomplete, we hope to continue to append the library as much as we can and in due time find its functionality competitive with that of R Performance Analytics.

**Authors**

Dominic Pazzula

Carter Johnston

**[ActivePremium](#ActivePremium_TOC)** Active Premium or Active Return

**Description**

The return on an investment’s annualized return minus the benchmark’s annualized return.

**Usage**

**%**ActivePremium(Returns, BM=)

%ActivePremium(Returns, BM=, scale=, method=)

%ActivePremium(Returns, BM=, scale=, method=, dateColumn=, outData=)

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Specifies the benchmark asset or index in the returns data set.

Scale- The number of periods per year used in the annualized calculation.

Method- option to annualize using geometric or arithmetic chaining. {GEOMETRIC, ARITHMETIC} [Default= GEOMETRIC]

dateColumn- specifies the date column in the data set. [Default= Date]

outData- specifies the name of the output active premium. [Default= active\_premium]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[CoMoments](#name_CoMoments)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***ActivePremium***(prices, BM= SPY);

/\*Or\*/

/\*%ActivePremium(prices, BM= DOW, scale= 252, method= GEOMETRIC, dateColumn= Date, outData= active\_premium);\*/

**[Adjusted\_SharpeRatio](#adjustedSharpe_TOC)** Adjusted Sharpe Ratio of the return distribution

**Description**

Adjusted Sharpe ratio was introduced to adjust for skewness and kurtosis by incorporating a penalty for negative skewness and excess kurtosis.

**Usage**

**%**Adjusted\_SharpeRatio (Returns)

%Adjusted\_SharpeRatio(Returns, Rf =, scale=)

%Adjusted\_SharpeRatio(Returns, Rf=, scale=, VARDEF=, dateColumn=, outData=)

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

Rf- the value or variable representing the risk free rate of return.

Scale- The number of periods per year used in the annualized calculation. [Default= 1]

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- specifies the name of the output Adjusted Sharpe ratios [Default= adjusted\_SharpeRatio]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Sharpe\_Ratio](#name_SharpeRAtio)  [SharpeRatio\_annualized](#name_SharpeRatioAnnualized)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Adjusted\_SharpeRatio***(prices);

/\*Or\*/

/\*%Adjusted\_SharpeRatio(prices, Rf= 0.01/252, scale= 252, dateColumn= Date, outData= adjusted\_SharpeRatio);\*/

**[Appraisal\_Ratio](#appraisalRatio_TOC)** Appraisal ratio of the return distribution

**Description**

Appraisal ratio is the Jensen’s alpha adjusted for specific risk. The numerator is divided by specific risk instead of total risk.

**Details**

Modified Jensen’s alpha is Jensen’s alpha divided by beta.

Alternative Jensen’s alpha is Jensen’s alpha divided by systematic risk.

**Usage**

**%**Appraisal\_Ratio(Returns, BM=, option=)

%Appraisal\_Ratio(Returns, BM=, Rf=, scale=, option=)

%Appraisal\_Ratio(Returns, BM=, Rf=, scale=, option=, method=, VARDEF=, dateColumn=, outData=)

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Specifies the benchmark asset or index in the returns data set.

Rf- the value or variable representing the risk free rate of return.

Scale- The number of periods per year used in the annualized calculation. [Default= 1]

Option- required. {APPRAISAL, MODIFIED, ALTERNATIVE}. Choose “appraisal” to calculate the appraisal ratio, “modified” to calculate the modified Jensen’s alpha, or “alternative” to calculate alternative Jensen’s alpha.

Method- option to annualize Jensen’s alpha using geometric chaining or arithmetic chaining. {GEOMETRIC, ARITHMETIC} [Default= GEOMETRIC]

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- specifies the name of the output Appraisal ratios [Default= appraisal\_ratio]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[CAPM\_JensenAlpha](#name_CAPMJensenalpha)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Appraisal\_Ratio***(prices, BM= SPY, Rf= 0, option= appraisal);

/\*Or\*/

/\*%Appraisal\_Ratio(prices, BM= SPY, Rf= 0.01/252, scale= 252, option= modified, method= GEOMETRIC, dateColumn= Date, outData= appraisal\_ratio);\*/

[**BetaCoMoments**](#betaCo_TOC) Functions to calculate systematic or beta co-moments of return series

**Description**

Calculate higher co-moment betas, or ‘systematic’ variance, skewness, and kurtosis matrices.

Beta Covariance is equivalent to Covariance over Variance, Beta Coskewness is equivalent to Coskewness over skewness, and Beta CoKurtosis is equivalent to CoKurtosis over Kurtosis.

**Usage**

**%**BetaCoMoments(Returns)

%BetaCoMoments(Returns, dateColumn=)

%BetaCoMoments(Returns, dateColumn=, outBetaCoVar=, outBetaCoSkew=, outBetaCoKurt=)

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

dateColumn- specifies the date column in the data set. [Default= Date]

outBetaCoVar- specifies the name of the output Beta Covariance matrix. [Default= BetaM2]

outBetaCoSkew- specifies the name of the output Beta Coskewness matrix. [Default= BetaM3]

outBetaCoKurt- specifies the name of the output Beta Cokurtosis matrix. [Default= BetaM4]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[CoMoments](#name_CoMoments)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***BetaCoMoments***(prices);

/\*Or\*/

/\*%BetaCoMoments(prices, dateColumn= Date,outBetaCoVar=BetaM2, outBetaCoSkew= BetaM3, outBetaCoKurt=BetaM4);\*/

[**CAPM\_Alpha\_Beta**](#CAPMalphabeta_TOC) calculate single factor model (CAPM) alpha and beta

**Description**

This macro calculates values of Alpha and Beta as defined by CAPM (single factor model), effectively combining the wrapper functions of CAPM.alpha and CAPM.beta in the R performance analytics package.

**Details**

“Alpha” purports to be the measure of a manager’s skill by measuring the portion of the manager’s returns not attributable to “Beta”, or the portion of performance attributable to a benchmark asset or index.

It should be noted that the classical CAPM model has been almost completely discredited by academics, however, it is a good example of a simple single factor model comparing an asset to an arbitrary benchmark.

The CAPM Beta is the beta of an asset to the variance and covariance of an initial portfolio. It is used to determine diversification potential. Beta is often thought of as the slope of the regression line used to determine the risk premium of a returns time series. Alpha is thought of as the intercept of this regression line.

Beta can be calculated as:

**Usage**

**%**CAPM\_Alpha\_Beta (Returns, BM=, Rf=);

%CAPM\_Alpha\_Beta (Returns, BM=, Rf=, dateColumn=, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Names variable in the data set containing returns of the benchmark asset or index.

Rf- value or variable representing the risk free rate of return.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output data set containing values of alpha and beta. [Default= alphas\_and\_betas]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[CAPM\_Epsilon](#name_CAPMepsilon)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***CAPM\_Alpha\_Beta***(prices, BM= SPY, Rf= **0.01**/**252**);

/\*Or\*/

/\*%CAPM\_Alpha\_Beta(prices, BM= SPY, Rf= IBM, dateColumn= Date, outData= alphas\_and\_betas);\*/

**[CAPM\_Epsilon](#CAPMepsilon_TOC)** Regression epsilon of the return distribution

**Description**

The regression epsilon is an error term measuring the vertical distance between the return predicted by the equation and the real result as defined by the capital asset pricing model.

**Details**

The regression epsilon is given by the following formula:

Where is the regression alpha, is the regression beta, is the portfolio return and b is the benchmark return.

**Usage**

%CAPM\_Epsilon(Returns, BM=, Rf=, scale=);

%CAPM\_Epsilon(Returns, BM=, Rf=, scale=, dateColumn=, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Names variable in the data set containing returns of the benchmark asset or index.

Rf- value or variable representing the risk free rate of return.

Scale- required. Specifies the number of periods in one year. [Daily= 252, Monthly= 12, Quarterly= 4]

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output data set containing values of epsilon. [Default= epsilon]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[CAPM\_Alpha\_Beta](#name_CAPMalphabeta)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***CAPM\_Epsilon***(prices, BM= SPY, Rf= **0.01**/**252**);

/\*Or\*/

/\*%CAPM\_Epsilon(prices, BM= SPY, Rf= IBM, scale= 252, dateColumn= Date, outData= epsilon);\*/

[CAPM\_JensenAlpha](#CAPMJensenalpha_TOC) Jensen’s alpha of the return distribution

**Description**

The Jensen’s alpha is the intercept of the regression equation in the Capital Asset Pricing Model and is in effect the excess return adjusted for systematic risk.

**Details**

Jensen alpha is calculated as:

.

where is the risk free rate, is the regression beta, is the portfolio return and b is the benchmark return.

**Usage**

%CAPM\_JensenAlpha(Returns, BM=);

%CAPM\_JensenAlpha(Returns, BM=, Rf=, scale=, method=, dateColumn=, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Specifies the benchmark asset or index.

Rf- the value or variable specified as the risk free rate of return.

Scale- The number of periods per year used in the annualized calculation. [Default= 1]

Method- option to implement geometric or arithmetic chaining when annualizing.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output data set containing values of Jensen alphas. [Default= Jensen\_Alpha]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[CAPM\_alpha\_beta](#name_CAPMalphabeta)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***CAPM\_JensenAlpha***(prices, BM= SPY);

/\*Or\*/

/\*%CAPM\_JensenAlpha(prices, BM= SPY, Rf= 0.01/252, scale= 252, method= GEOMETRIC, dateColumn= Date, outData= Jensen\_Alpha);\*/

**[Centered\_Moments](#CenteredMoments_TOC)** calculate centered moments

**Description**

This macro is used internally by SAS Performance Analytics to calculate centered moments for a multivariate distribution as well as the standardized moments of a portfolio distribution. However, it can be called independently for those who wish to calculate centered moments directly.

**Details**

The *n*-th centered moment is calculated as:

.

Centered\_Moments returns values of the centered variance, centered skewness, and centered kurtosis in separate tables.

**Usage**

%Centered\_Moments(Returns);

%Centered\_Moments(Returns, dateColumn=, outCenteredVar=, outCenteredSkew=, outCenteredKurt=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

dateColumn- specifies the date column in the data set. [Default= Date]

outCenteredVar- output data set containing values of centered variance. [Default= centered\_Var]

outCenteredSkew- output data set containing values of centered skewness. [Default= centered\_Skew]

outCenteredKurt- output data set containing values of centered kurtosis. [Default= centered\_Kurt]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Return\_Centered](#name_Return_Centered)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Centered\_Moments***(prices);

/\*Or\*/

/\*%Centered\_Moments (prices, dateColumn= Date, outCenteredVar= centered\_Var, outCenteredSkew= centered\_Skew, outCenteredKurt= centered\_Kurt);\*/

**[Chart\_Histogram](#ChartHistogram_TOC)** Histogram of returns

**Description**

Create a histogram of returns with the option to overlay a density curve to show approximate fit.

**Usage**

%Chart\_Histogram(Returns, asset, title=);

%Chart\_Histogram(Returns, asset, scale=, title=, bindwidth=, density=, color=, dateColumn=)

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

Asset- required. Specifies the variable for which to calculate the histogram of returns.

Scale- Optional. Specifies whether the y-axis should go by probability or frequency. {count, percent, proportion}. [Default= count]

Title- give title for histogram [Default= &asset]

bindwidth - Optional. Specifies the range of returns to select for each bar. [Default= 0.001]

Density- Option to overlay a normal density on the histogram for normal approximation. If true, [Density= Density]

color- Optional. Change the color of the histogram bins. [Default= cornflowerblue]

densitycolor- Optional. Change the color of the density line. [Default= red]

histogramTransparency- Optional. Change the transparency of the histogram bins. [Default= 0.8]

keepOutliers- Optional. Delete outlier returns from the histogram within the range of Q1- 1.5IQR and Q3+1.5IQR. [Default= TRUE]. {TRUE, FALSE}

qqplot - Optional. Display a QQ Plot in addition to the histogram. [Default= FALSE]. {TRUE,FALSE}

rug - Optional. Display a fringe plot overlayed onto the histogram. [Default= FALSE]. {TRUE,FALSE}

dateColumn- specifies the date column in the data set. [Default= Date]

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Chart\_Histogram***(prices, asset= IBM);

/\*Or\*/

/\*%Chart\_Histogram(prices, asset= IBM, scale=percent, title= My Histogram, density= TRUE, dateColumn= Date);\*/

[**Chart\_Co****rrelation**](#name_ChartCorrelation) Correlation matrix of returns

**Description**

Create a table showing the correlation of returns between every two assets.

**Usage**

%Chart\_Correlation(returns, title=, histogram=)

%Chart\_Correlation(returns, title=, histogram=, histogramDensity=, color=, symbol=, size= )

**Arguments**

returns - Required. Data Set containing returns.

title - Required. Title for histogram. Default= Portfolio Asset Correlations

histogram - Optional. Option to insert histograms for each asset along the diagonal of the plot matrix. Default= FALSE

histogramDensity - Optional. Selects a type of density to overlay on histograms along the diagonal. Default= normal {Normal, Kernel}

color - Optional. Change the color of the scatter plot points. Default= cornflowerblue

symbol - Optional. Change the symbol of the scatter plot points. Default= circle

See list of possible symbols at SAS product documentation (markerattrs symbol)

size - Optional. Change the size (in pixels) of the plot points. Default= 6

ellipse - Option to add a predictive ellipse to scatter plots. Default= FALSE {True, False}

ellipseType - Optional. If ellipse is overlayed, specifies type. Default= predicted {mean, predicted}

alpha - Optional. If ellipse is overlayed, specifies value of alpha for predictive bands. Default= 0.05

dateColumn - Optional. Specifies the date column for returns in the data set. Default= Date

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Chart\_Correlation***(prices);

/\*Or\*/

/\*%Chart\_Correlation(prices, title= Correlation Chart, histogram= TRUE, histogramDensity=kernel, color=red, symbol= star, size=8, ellipse=TRUE, ellipseType=mean, dateColumn=DATE);\*/

**[CoMoments](#CoMoments_TOC)**  Macro for calculating the co-moments of financial time series

**Description**

Calculates the co-skewness and co-kurtosis as the skewness and kurtosis of two assets with reference to one another. This data is input into two separate matrices. CoMoments is an internal macro used in table\_HigherMoments, but can be exposed if the user wishes to see the output directly.

**Details**

The individual elements of the co-skewness matrix can be obtained as:

.

Similarly, the individual elements of the co-kurtosis matrix can be obtained as:

.

**Usage**

%CoMoments(Returns);

%CoMoments(Returns,dateColumn=, outCoSkew=, outCoKurt=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

dateColumn- specifies the date column in the data set. [Default= Date]

outCoSkew- output co-skewness matrix. [Default= M3]

outCoKurt- output co-kurtosis matrix. [Default= M4]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Return\_Centered](#name_Return_Centered), [BetaCoMoments](#name_BetaCo)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***Return\_Calculate***(prices);

%***CoMoments***(prices); /\*Or\*/

/\*%CoMoments (prices, dateColumn= Date, outCoSkew= M3, outCoKurt= M4);\*/

**[Fama\_Beta](#famabeta_TOC)** Fama beta of the return distribution

**Description**

Fama beta is a beta used to calculate the loss of diversification. It is made so that the systematic risk is equivalent to the total portfolio risk.

**Details**

Fama beta is calculated as:

where is the portfolio standard deviation and is the market risk.

**Usage**

%Fama\_beta(Returns, BM=);

%Fama\_beta(Returns, BM=, dateColumn=, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Names the benchmark asset or index in the data set.

Scale- optional. Number of periods in a year {any positive integer, ie daily scale= 252, monthly scale= 12, quarterly scale= 4}. [Defaul=1]

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- names the output data set with values of Fama beta. [Default= fama\_beta]

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***Return\_Calculate***(prices);

%***Fama\_beta***(prices, BM= SPY);

/\*Or\*/

/\*%Fama\_beta(prices,BM= SPY, dateColumn= Date, outData= fama\_beta);\*/

**[Geo\_Mean](#GeoMean_TOC)** calculate the geometric mean of the observation series

**Description**

The geometric mean is a measure of central tendency, using multiplication instead of the traditional addition to summarize data values. Geometric means are useful summaries for highly skewed data. Do not use a geometric mean if there are negative or zero values in the data set.

**Details**

Geo\_Mean is intended as a wrapper function to be used inside other macros that require it. However, the user can call Geo\_Mean if they so choose. The geometric mean is given by one of two formulas:

**Usage**

%Geo\_Mean (Returns, BM=, Rf=, scale=);

%Geo\_Mean(Returns, BM=, Rf=, scale=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with of systematic risk. [Default= “\_geoMean”]

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Geo\_Mean***(prices);

/\*Or\*/

/\*%Geo\_Mean(prices, dateColumn= Date, outData= \_geoMean);\*/

**[Information Ratio](#InformationRatio_TOC)** Active Premium over Tracking Error

**Description**

Information Ratio is defined as the Active Premium divided by the Tracking Error

**Details**

The information ratio relates the *degree* to which an investment has beaten the benchmark to the *consistency* with which the investment has beaten the benchmark. William Sharpe recommends the information ratio preferentially to the original Sharpe Ratio.

The information Ratio is given by the following formula:

**Information Ratio**=

where

**Usage**

%InformationRatio(Returns, BM=, scale=);

%InformationRatio(Returns,BM=, scale=, dateColumn=, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Names the benchmark asset or index variable in the data set.

Scale- optional. The number of periods in a year (daily scale= 252, monthly= 12) for which the return is to be annualized. Default= 1.

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output data set with information ratios. [Default= Info\_Rat]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[TrackingError](#name_trackingError)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Information\_Ratio***(prices, BM= SPY, scale= **252**);

/\*Or\*/

/\*%Information\_Ratio(prices, BM= SPY, scale= 252, dateColumn= Date, outData= Info\_Rat);\*/

**[MSquared](#MSquared_TOC)** M squared of the return distribution

**Description**

M squared is a risk adjusted return useful to judge the size of relative performance between differents portfolios. With it you can compare portfolios with different levels of risk.

**Details**

**Usage**

%MSquared (Returns, BM=);

%MSquared(Returns, BM=, Rf=, scale=, method=, dateColumn=, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Names the benchmark asset or index variable in the data set.

Rf- specifies the variable or value of the risk free rate of return.

Scale- optional. The number of periods in a year (daily scale= 252, monthly= 12) for which the return is to be annualized. Default= 1.

Method- option to implement either geometric or arithmetic chaining when annualizing returns.

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output data set with M squared values. [Default= MSquared]

**Author**

Dominic Pazzula, Carter Johnston

**Notes**

The authors would like to express that this macro is distinct from the function given by R performance analytics due to disagreements with its implementation. The definition of M squared is the Sharpe Ratio multiplied by the standard deviation of the benchmark plus the risk free rate. When annualizing M squared, the geometric average ought to be calculated as the geometric average of , not the geometric average of . For this reason, results between the macro and its equivalent in R will be different.

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***MSquared***(prices, BM= SPY, scale= **252**);

/\*Or\*/

/\*%MSquared(prices, BM= SPY, Rf= 0.01/252, scale= 252, method= GEOMETRIC, dateColumn= Date, outData= MSquared);\*/

**[Prices](#prices_TOC)** Selected price series example data

**Description**

An example price timeseries data set produced by %get\_Stocks which was used to test the majority of the macros in this library, as well as the data set used in examples in this documentation.

**Usage**

%Return\_Calculate(prices);

**Format**

SAS data set

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

[Return\_Annualized](#Return_Annualized_TOC) calculate an annualized return for comparing instruments with different length history

**Description**

Calculate annualized returns for comparison between instruments with different length history.

**Details**

Annualized returns are useful for comparing two assets. Observations are scaled to an annual scale by raising the compound return to the number of periods in a year, and taking the root to the number of total observations:

where scale is the number of periods in a year, and n is the total number of observations in terms of periods.

For simple arithmetic returns, the formula is simply

**Usage**

%Return\_Annualized (Returns, scale=);

%Return\_Annualized(Returns, scale=, method=, dateColumn, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

Scale- required. The number of periods in a year (daily scale= 252, monthly= 12) for which the return is to be annualized.

Method- {GEOMETRIC, ARITHMETIC} –option to implement geometric or arithmetic chaining. [Default= GEOMETRIC]

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output data set with annualized returns. [Default= annualized\_returns]

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Return\_Annualized***(prices, scale= **252**, method= GEOMETRIC)

/\*Or\*/

/\*%Return\_Annualized(prices, scale= 252, method= ARITHMETIC, dateColumn= Date, outData= annualized\_returns);\*/

**[Return\_Calculate](#Return_Calculate_TOC)** calculate simple or compound returns from prices

**Description**

Calculate simple or compound returns from a series of prices. Option to update the table in place or create new output.

**Details**

There are two requirements for Return\_Calculate that should be made clear. First, price data is assumed to be regular. Prices can be for any time scale as long as the data consists of regular observations. Irregular observations require time period scaling to be comparable. Second, if corporate actions, such as a stock-split, dividends, or other adjustments such as time or money weighting are to be taken into account, those calculations must be made separately. This macro assumes fully adjusted close prices as input. The default for this function is to use discrete returns, as most other macros in the library utilize compound chaining by default.

**Usage**

%Return\_Calculate (Prices);

%Return\_Calculate(Prices, method=, dateColumn=, updateInPlace=, outData=);

**Arguments**

Prices- required. Data Set containing prices

Method- {LOG, DISCRETE} – compound or simple returns. [Default= DISCRETE]

dateColumn- specifies the date column in the data set. [Default= Date]

updateInPlace- {True, False} – update the &prices Data Set in place. [Default= TRUE]

outData- output Data Set with returns. Only used if updateInPlace= FALSE [Default= “returns”]

**Author**

Dominic Pazzula

**See Also**

[Return\_Cumulative](#name_Return_Cumulative)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

/\*Or\*/

/\*%Return\_Calculate(prices, method= DISCRETE, dateColumn= Date, updateInPlace= TRUE, outData= returns);\*/

[Return\_Centered](#Return_Centered_TOC) calculate centered returns

**Description**

Calculate the values of centered returns from a series of returns.

**Details**

The centered return is calculated as return minus the expected return, or mean, of an instrument. It is used in the calculations of higher moments.

**Usage**

%Return\_Centered (Returns);

%Return\_Centered(Returns, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with centered returns. [Default= “centered\_returns”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[CoMoments](#name_CoMoments), [table\_HigherMoments](#name_tableHigherMoments)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Return\_Centered***(prices);

/\*Or\*/

/\*%Return\_Centered(prices, dateColumn= Date, outData= centered\_returns);\*/

**[Return\_Cumulative](#Return_Cumulative_TOC)** calculate a compounded cumulative return

**Description**

Calculates the cumulative return over a period of time, producing simple or geometric returns.

**Details**

The product of all individual period returns is

If calculating the cumulative return using the simple arithmetic method, cumulative returns are equivalent to the sum of all returns.

**Usage**

%Return\_Cumulative (Returns);

%Return\_Cumulative(Returns, method=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

Method- {GEOMETRIC, ARITHMETIC} – specifies compound or simple returns. [Default= GEOMETRIC]

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with cumulative returns. [Default= “cumulative\_returns”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Return\_Annualized](#name_Return_Annualized)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Return\_Cumulative***(prices);

/\*Or\*/

/\*%Return\_Cumulative(prices, method= GEOMETRIC, dateColumn= Date, outData= cumulative\_returns);\*/

**[Return\_Excess](#Return_Excess_TOC)** Calculate the returns of an asset in excess of the given risk free rate

**Description**

Calculates the returns of an asset in excess of the given “risk free rate” for the period.

**Details**

Ideally, the risk free rate will be for each period in which returns data is available, but a single average risk free rate for the period will work with this macro. While the Rf parameter is named after the risk free rate, any timeseries is allowed. A common alteration would be to find the excess returns over a benchmark asset or index.

**Usage**

%Return\_Excess (Returns, Rf=);

%Return\_Excess(Returns, Rf=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

Rf- required. A value or vector representing the risk free rate of return.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with risk premium. [Default= “risk\_premium”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Return\_Calculate](#name_Return_Calculate)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Return\_Excess***(prices, Rf= 0.01/252);

/\*Or\*/

/\*%Return\_Excess(prices, Rf= SPY, dateColumn= Date, outData= risk\_premium);\*/

**[Sharpe\_Ratio](#Sharpe_Ratio_TOC)** calculate a traditional Sharpe Ratio of return over standard deviation.

**Description**

The Sharpe ratio is simply the return per unit of risk (represented by variability). The original Sharpe ratio uses standard deviation of returns as unit of risk.

**Details**

The Sharpe Ratio, in its original form, is the expected excess return over the standard deviation of excess return. The higher the Sharpe ratio, the better the combined performance of “risk” and return. It is worth mentioning that William Sharpe, the originator of the Sharpe ratio, now recommends the Information ratio preferentially to the original Sharpe Ratio.

It should be noted that the equivalent function in R performance analytics allows the user to calculate modified Sharpe Ratios with Value at Risk (VaR) or Expected Shortfall (ES) instead of Standard Deviation. We are working on adding these options to %Sharpe\_Ratio and will hopefully have this updated soon.

**Usage**

%Sharpe\_Ratio (Returns, Rf=);

%Sharpe\_Ratio(Returns, Rf=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

Rf- required. A value or vector representing the risk free rate of return.

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with Sharpe ratios. [Default= “SharpeRatio”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Information\_Ratio](#name_InformationRatio)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Sharpe\_Ratio***(prices, Rf= 0.01/252);

/\*Or\*/

/\*%Sharpe\_Ratio(prices, Rf= SPY, dateColumn= Date, outData= SharpeRatio);\*/

**[SharpeRatio\_Annualized](#SharpeRatioAnnualized_TOC)** calculate annualized Sharpe ratio

**Description**

The Sharpe ratio is a risk-adjusted measure of return that uses standard deviation to represent risk. The annualized Sharpe ratio is calculated using both annualized returns and annualized standard deviation to measure return.

**Details**

The Sharpe ratio is simply the return per unit of risk (represented by variance). The higher the Sharpe ratio, the better the combined performance of “risk” and return. This macro annualizes this ratio based on the scale parameter which specifies the number of periods for which there is data in one year.

Using an annualized Sharpe ratio is useful for comparison of multiple return streams where length of holdings are not necessarily equal.

**Usage**

%SharpeRatio\_Annualized (Returns, Rf=, scale=);

%SharpeRatio\_Annualized(Returns, Rf=, scale=, method=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

Rf- required. A value or vector representing the risk free rate of return.

Scale- required. Specifies the number of periods in one year. [Daily= 252, Monthly= 12, Quarterly= 4]

Method- option for geometric or arithmetic chaining. {GEOMETRIC, ARITHMETIC} [Default= GEOMETRIC]

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with annualized Sharpe ratios. [Default= “Annualized\_SharpeRatio”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Sharpe\_Ratio](#name_SharpeRAtio)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***SharpeRatio\_Annualized***(prices, Rf= 0.01/252, scale= 252);

/\*Or\*/

/\*%SharpeRatio\_Annualized(prices, Rf= SPY, scale= 252, method= GEOMETRIC, dateColumn= Date, outData= SharpeRatio);\*/

**[Specific\_Risk](#SpecificRisk_TOC) specific risk of the return distribution**

**Description**

Specific risk is the standard deviation of the error term in the regression equation. Specific risk is not the same as market risk. Market risk is the standard deviation of the benchmark asset or index.

**Details**

Specific risk can be thought of as the standard deviation of the regression epsilon, or it can be thought of as the square root of total risk squared minus systematic risk squared.

**Usage**

%Specific\_Risk (Returns, BM=, Rf=, scale=);

%Specific\_Risk(Returns, BM=, Rf=, scale=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

BM- required. Names variable containing returns of benchmark asset from the returns data set.

Rf- required. A value or vector representing the risk free rate of return.

Scale- required. Specifies the number of periods in one year. [Daily= 252, Monthly= 12, Quarterly= 4]

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with specific risk values. [Default= “Risk\_Specific”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Systematic\_Risk](#name_SystematicRisk), [table\_SpecificRisk](#name_tableSpecificRisk)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Specific\_Risk***(prices, BM= SPY, Rf= 0.01/252, scale= 252);

/\*Or\*/

/\*%Specific\_Risk(prices, BM= SPY, Rf= IBM, scale= 252, dateColumn= Date, outData= Risk\_specific);\*/

**[Standard\_Deviation](#StandardDeviation_TOC)  calculates standard deviation for univariate and multivariate series**

**Description**

Calculates the standard deviation, or “risk”, for univariate and multivariate series. This macro contains the option to annualize the standard deviation given the extra parameter, scale.

**Details**

The standard deviation is calculated using the following formula:

Where = return observation of asset, = the mean return of the asset, and n= number of observations.

The annualized standard deviation is calculated as:

**Usage**

%Standard\_Deviation (Returns);

%Standard\_Deviation(Returns, annualized=, scale=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

annualized - Optional. Option to annualize the standard deviation. {TRUE, FALSE} [Default= FALSE]

scale - Optional. Number of periods in a year {any positive integer, ie daily scale= 252, monthly scale= 12, quarterly scale= 4}. [Default= 1]

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with standard deviations. [Default= “StdDev”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[StdDev\_Annualized](#name_StdDevAnnualized)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Standard\_Deviation***(prices);

/\*Or\*/

/\*%Standard\_Deviation(prices, dateColumn= Date, outData= StdDev);\*/

[StdDev\_Annualized](#StdDevAnnualized_TOC) calculate a multiperiod or annualized standard deviation

**Description**

Calculate the standard deviation of a set of observations and estimate the annualized standard deviation based on the number of periods in a year.

**Details**

To normalize standard deviation across multiple periods, we multiply by the square root of the number of periods we wish to calculate over. To annualize standard deviation, we multiply by the square root of the number of periods per year.

**Usage**

%StdDev\_Annualized (Returns, scale=);

%StdDev\_Annualized(Returns, scale=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

scale- If annualized= TRUE, then scale specifies the number of periods in one year. [Daily= 252, Monthly= 12, Quarterly= 4]

annualized - optional. Annualize the standard deviation. {TRUE,FALSE} [Default= FALSE]

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with of systematic risk. [Default= “annualized\_StdDev”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Standard\_Deviation](#name_StandardDeviation)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***StdDev\_Annualized***(prices, scale=252);

/\*Or\*/

/\*%StdDev\_Annualized(prices, scale= 252, dateColumn= Date, outData= annualized\_StdDev);\*/

**[Systematic\_Risk](#SystematicRisk_TOC)** Systematic risk of the return distribution

**Description**

Systematic risk is defined as the product of beta and market risk. Market risk is the standard deviation of the benchmark asset or index. The systematic risk is then annualized for comparison purposes.

**Details**

Where is systematic risk, is the regression beta, and is the market risk.

**Usage**

%Systematic\_Risk (Returns, BM=, Rf=, scale=);

%Systematic\_Risk(Returns, BM=, Rf=, scale=, dateColumn=, outData=);

**Arguments**

Returns- required. Data Set containing returns.

BM- required. Names variable containing returns of benchmark asset from returns data set.

Rf- required. Either a value or vector representing the risk free rate of return.

Scale- If annualized= TRUE, then scale specifies the number of periods in one year. [Daily= 252, Monthly= 12, Quarterly= 4]

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with of systematic risk. [Default= “Risk\_systematic”]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Specific\_Risk](#name_SpecificRisk), [table\_SpecificRisk](#name_tableSpecificRisk)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***Systematic\_Risk***(prices, BM= SPY, Rf= 0.01/252, scale=252);

/\*Or\*/

/\*%Systematic\_Risk(prices, BM= SPY, Rf= IBM, scale= 252, dateColumn= Date, outData= Risk\_systematic);\*/

**[Table\_Annualized\_Returns](#tableAnnualizedReturns_TOC)** Annualized returns summary: statistics and stylized facts

**Description**

This macro returns a table containing annualized return, annualized standard deviation, and annualized Sharpe ratio.

**Usage**

%table\_Annualized\_Returns (Returns, Rf=, scale=);

%table\_Annualized\_Returns(Returns, Rf=, scale=, method=, dateColumn=, outData=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

Rf- required. Either a value or vector representing the risk free rate of return.

scale- If annualized= TRUE, then scale specifies the number of periods in one year. [Daily= 252, Monthly= 12, Quarterly= 4]

method- option to compute returns using geometric or arithmetic chaining. {GEOMETRIC, ARITHMETIC} [Default= GEOMETRIC]

VARDEF - optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with annualized returns statistics. [Default= “annualized\_table”]

printTable- option to print the output data set. {PRINT, NOPRINT} [Default= NOPRINT]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Return\_Annualized](#name_Return_Annualized), [Standard\_Deviation](#name_StandardDeviation), [SharpeRatio\_Annualized](#name_SharpeRatioAnnualized)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_Annualized\_Returns(***prices, Rf= 0.01/252, scale=252);

/\*Or\*/

/\*%table\_Annualized\_Returns(prices, Rf= SPY, scale= 252,method= GEOMETRIC, dateColumn= DATE, outData= annualized\_table, printTable= PRINT);

**[Table\_AutoCorrelation](#tableAutoCorrelations_TOC)** table for calculating autocorrelation coefficients and significance

**Description**

Produces a table consisting of autocorrelation coefficients *ρ* and corresponding significance levels as measured by the Ljung-Box test Q-statistic for each asset.

More information on the Ljung-Box test and the accompanying Q-test can be found here:

<https://en.wikipedia.org/wiki/Ljung%E2%80%93Box_test>

**Usage**

%Table\_AutoCorrelation (Returns, Rf=, scale=);

%Table\_AutoCorrelation(Returns, Rf=, scale=, method=, annualized=, dateColumn=, outData=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

Nlag- required. Specifies the number of lags to perform autocorrelations.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with annualized returns statistics. [Default= “AutoCorrelations”]

printTable- Optional. Option to print table. {PRINT, NOPRINT}. Default= [NOPRINT]

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_AutoCorrelation(***prices, nlag= 6);

/\*Or\*/

/\*%table\_AutoCorrelation(prices, nlag= 6, dateColumn= DATE, outData=AutoCorrelations, printTable= PRINT);

**[Table\_CalendarReturns](#tableCalendarReturns_TOC)** Monthly and calendar year return table

**Description**

Returns a table of returns formatted with years in rows, months in columns, and a total return in the last column.

**Details**

To mimic results from R performance analytics, the user should specify one asset by name to be printed in the parameters of the macro. If no asset name is found, the table will show results for all assets in order by asset name.

**Usage**

%table\_CalendarReturns(Returns);

%table\_CalendarReturns(Returns, method=, dateColumn=, outData=, printTable=, name=);

**Arguments**

Returns- required. Data Set containing returns.

Rf- required. Either a value or vector representing the risk free rate of return.

Method- option to compute returns using geometric or arithmetic chaining. {GEOMETRIC, ARITHMETIC} [Default= GEOMETRIC]

Annualized- option to annualize the standard deviation to scale.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with annualized returns statistics. [Default= “calendar\_returns”]

printTable- option to print output data set. {PRINT, NOPRINT} [Default= NOPRINT]

name- specifies a single variable or asset name to print if printTable= PRINT.

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_CalendarReturns (***prices);

/\*Or\*/

/\*%table\_CalendarReturns(prices, method= GEOMETRIC, dateColumn= DATE, outData= Calendar\_Returns, printTable= PRINT, name= IBM);

[Table\_Correlation](#tableCorrelations_TOC) calculate correlations of multiple assets

**Description**

Calculates the correlation, significance, and confidence intervals for correlation estimates with an asset or benchmark index.

**Usage**

%table\_Correlation(Returns, returnsCompare=);

%table\_Correlation(Returns, returnsCompare=, dateColumn=, outData=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

ReturnsCompare- required. Asset or benchmark index to calculate correlations with.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with annualized returns statistics. [Default= “Correlations”]

printTable- option to print table. {PRINT, NOPRINT}, Default= [NOPRINT].

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_Correlation(***prices, returnsCompare= GE);

/\*Or\*/

/\*%table\_Correlation(prices,returnsCompare= SPY, dateColumn= DATE, outData=Correlations, printTable= PRINT);

**[Table\_Distributions](#Table_Distributions_TOC)** Distribtuions summary: statistics and stylized facts

**Description**

Table containing, standard deviation, skewness, sample standard deviation, kurtosis, excess kurtosis, sample skewness, and sample excess kurtosis.

**Usage**

%table\_Distributions(Returns);

%table\_Distributions(Returns, dateColumn=, outData=, digits=, scale=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with distribution statistics. [Default= “Correlations”]

digits- specifies the amount of digits to display in output. [Default= 4].

Scale- Denotes the scale for which to annualize the standard deviation. [Default= 1]

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

printTable- option to print table. {PRINT, NOPRINT}, Default= [NOPRINT].

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_Distributions(***prices);

/\*Or\*/

/\*%table\_Distributions(prices, dateColumn= DATE, outData=distribution\_table, digits= 8, scale= 252, printTable= PRINT);

[Table\_HigherMoments](#tableHigherMoments_TOC) Higher Moments summary: Statistics and stylized facts

**Description**

Summary of the higher moments and co-moments of the return distribution. Used to determine diversification potential. Also called “systematic” moments.

**Usage**

%table\_HigherMoments(Returns);

%table\_HigherMoments(Returns, dateColumn=, outData=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with “systematic” moments. [Default= “Higher\_moments”]

printTable- option to print table. {PRINT, NOPRINT}, Default= [NOPRINT].

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[BetaCoMoments](#name_BetaCo), [CoMoments](#name_CoMoments)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_HigherMoments(***prices);

/\*Or\*/

/\*%table\_HigherMoments(prices, dateColumn= DATE, outData=Higher\_Moments, printTable= PRINT);

**[Table\_InformationRatio](#tableInformationRatio_TOC)** Information Ratio summary: Statistics and stylized facts

**Description**

Table of the Tracking error, annualized tracking error, and information ratio.

**Usage**

%table\_InformationRatio(Returns, BM=);

%table\_InformationRatio(Returns, BM=, scale=, dateColumn=, outData=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

BM- Required. Specifies the variable name of benchmark asset or index in the returns data set.

scale- Optional. Number of periods in a year {any positive integer, ie daily scale=252, monthly scale=12, quarterly scale=4}. [Default=1]

dateColumn- specifies the date column in the data set. [Default= Date]

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

outData- output Data Set with information ratio and tracking error. [Default= “table\_InformationRatio”]

printTable- option to print table. {PRINT, NOPRINT}, [Default= NOPRINT].

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Information\_Ratio](#name_InformationRatio), [TrackingError](#name_trackingError)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_InformationRatio(***prices, BM= SPY);

/\*Or\*/

/\*%table\_InformationRatio(prices, BM= DOW, scale= 252, dateColumn= DATE, outData=table\_InformationRatio, printTable= PRINT);

**[Table\_SpecificRisk](#tableSpecificRisk_TOC)** Specific Risk summary: Statistics and stylized facts

**Description**

Table of specific risk, systematic risk, and total risk of an asset or financial instrument. Total risk is assumed to be the standard deviation in this table.

**Usage**

%table\_SpecificRisk(Returns, BM=, Rf=);

%table\_SpecificRisk(Returns, BM=, Rf=, scale=, dateColumn=, outData=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

BM- required. Names variable containing returns of benchmark asset or index.

Rf- Either a constant or variable representing the risk free rate of return.

scale- Optional. Number of periods in a year {any positive integer, ie daily scale=252, monthly scale=12, quarterly scale=4}. [Default=1]

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with information ratio and tracking error. [Default= “table\_SpecificRisk”]

printTable- option to print table. {PRINT, NOPRINT}, Default= [NOPRINT].

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Specific\_Risk](#name_SpecificRisk), [Systematic\_Risk](#name_SystematicRisk), [Standard\_Deviation](#name_StandardDeviation)

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_SpecificRisk(***prices, BM= SPY);

/\*Or\*/

/\*%table\_SpecificRisk(prices, BM= DOW, Rf= 0.01/252, scale= 252, dateColumn= DATE, outData=table\_SpecificRisk, printTable= PRINT);

**[Table\_Stats](#tableStats_TOC)** Returns summary: Statistics and stylized facts

**Description**

Returns a table of basic statistics on a data set that match the period of the data passed in (e.g. monthly returns will return monthly statistics and daily returns will return daily stats…)

**Usage**

%table\_Stats(Returns);

%table\_Stats(Returns, alpha=, outData=, dateColumn=, digits=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

Alpha- specifies the significance level for the mean. [Default= 0.05]

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output Data Set with related statistics. [Default= “table\_SpecificRisk”]

digits= specifies the number of digits to display in the output data set.

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

printTable- option to print table. {PRINT, NOPRINT}, Default= [NOPRINT].

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_Stats(***prices);

/\*Or\*/

/\*%table\_Stats(prices, alpha= 0.05, outData= Stats, dateColumn= DATE, digits= 4,printTable= PRINT);

**[Table\_Variabliity](#tableVariability_TOC)** Variability summary: Statistics and stylized facts

**Description**

Table of mean absolute deviation, monthly standard deviation, and annualized standard deviation.

**Usage**

%table\_Variability(Returns, scale=);

%table\_Variability(Returns, scale=, dateColumn=, outData=, printTable=);

**Arguments**

Returns- required. Data Set containing returns.

scale- required. Denotes the scale for which to annualize the standard deviation.

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the format of the date column in the data set. [Default= Date]

outData- output Data Set with related statistics. [Default= “table\_Variability”]

printTable- option to print table. {PRINT, NOPRINT}, Default= [NOPRINT].

**Author**

Dominic Pazzula, Carter Johnston

**Examples**

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***table\_Variability(***prices, scale= 252);

/\*Or\*/

/\*%table\_Variability(prices, scale= 252,dateColumn= DATE, outData= variability\_table, printTable= PRINT);

**[TrackingError](#trackingError_TOC)** Calculate tracking error of returns against a benchmark

**Description**

The tracking error is the measure of the unexplained portion of performance relative to a benchmark asset or index.

**Details**

The tracking error is calculated by taking the square root of the average of the squared deviations between the investment’s returns and the benchmark’s returns, then multiplying the result by the square root of the scale of returns.

where

**Usage**

%TrackingError(Returns, BM=, scale=);

%TrackingError(Returns, BM=, annualized=, scale=, dateColumn=, outData=);

**Arguments**

Returns - required. Names the data set containing time series data of asset returns.

BM- required. Names the benchmark asset or index variable in the data set.

Annualized- option to annualize the tracking error. [Default= FALSE]

Scale- optional. The number of periods in a year (daily scale= 252, monthly= 12) if annualized= TRUE. [Default= 1].

VARDEF- Optional. Specify the variance divisor, DF, degree of freedom, n-1; N, number of observations, n. {N, DF} Default= DF.

dateColumn- specifies the date column in the data set. [Default= Date]

outData- output data set with tracking errors. [Default= tracking\_error]

**Author**

Dominic Pazzula, Carter Johnston

**See Also**

[Information\_Ratio](#name_InformationRatio)

**Examples**

%let dir=C:\SVN\SAS\_Perf\_Anly;

libname input "&dir";

/\*Include SASPerformanceAnalytics\*/

%include "&dir\macro\\*.sas" /nosource;

**data** prices;

set input.prices;

**run**;

%***return\_calculate***(prices);

%***TrackingError***(prices, BM= SPY);

/\*Or\*/

/\*%TrackingError(prices, BM= SPY, scale= 252, annualized= TRUE, dateColumn= Date, outData= tracking\_error);\*/