

Wall Risk Engine® User Guide

August 28, 2018

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1

Introducing Wall Risk Engine®

1.1 What is Wall Risk Engine®?

1.1.1 Overview

Wall Risk Engine® is a software component composed of 5 modules:

- Risk and expert modeling: estimating the risk (volatilities, correlations,...) and the performance (expected returns) of the components of your investment universe;
- Risk and performance analysis: analyzing (ex-ante and ex-post) the risk and performance properties of your financial instruments and portfolios;
- Robust portfolio optimization: designing tailored, dynamic and robust allocation strategies;
- Simulation and stress-tests: Simulating future values of financial instruments (simple and structured products) and portfolios, computing large-scale risk measures (VaR) based on Monte-Carlo approaches.
- Data preparation: outlier detection and data completion functionalities to prepare the data for the risk modeling and risk analysis.

1.1.2 Main features

Risk and performance modeling

This module provides advanced functionalities to build tailored risk and performance models, using both historical data and exogenous information such as anticipations, market-implied information or in-house scores. Monitoring and estimating the correlations (or covariances) across all asset classes is a very sensitive issue especially within a portfolio optimization or a pricing process. The risk models provided in Wall Risk Engine® rely on 3 main pillars:

- Computing reactive and dynamic historical estimations of the correlations and volatilities (or the variance/covariance matrix);
- Taking into account exogenous information (if any) about the correlations and the volatilities;

- Applying a relevant filter to ensure the robustness of the risk model (by removing the noise) and merge historical and exogenous information.

Risk and performance analysis

This module embeds a wide range of ex-ante and ex-post analysis designed to monitor the risk and performance of a given portfolio:

- Performance measures;
- Risk measures: Volatility, semi-volatility, tracking-error, robust VaR, drawdown,...;
- Ratios: Sharpe, Sortino, Information, Omega;
- 3rd and 4th moments of the distribution: skewness, kurtosis;
- Risk and performance contributions.

Robust portfolio optimization

This module provides optimization functions to design tailored portfolios:

- Minimization of the risk of the portfolio given some performance constraint;
- Risk Budgeting: maximization of the expected return of the portfolio given some volatility budget constraints;
- Market portfolio (with maximum Sharpe ratio);
- Off-the-shelf adaptive allocation model to build reactive and robust portfolios;

All these functionalities embed patented robust optimization techniques and provide reliable and pertinent portfolios, ensuring a smooth behaviour with respect to market changes. These allocation models are compatible with any type of linear constraints on the weights such as sectorial constraints, asset-level constraints.

Simulation and stress-testing

This module provides tools to:

- simulate financial instruments using factorial or dense simulation models,
- build scenario simulations based on exogenous factors,
- stress-test a financial instrument or a portfolio,
- compute risk measures (Value at Risk) on large-scale portfolios based on Monte-Carlo simulations.

Quant data preparation

This module provides functionalities to prepare the market data for the risk modeling and analysis:

- detecting outliers in multi-dimensional time series,
- completing historical time series with robust regression approaches.

1.2 Installation

1.2.1 Technical requirements

System requirements

All the functions are available for:

- Win32/Win64 architecture on Intel processors : Dynamic link library (DLL)
- Linux platforms - Shared library (SO)

The components are designed to be highly efficient on all types of scalar machines (PC's, workstations). The components can be used and integrated in different types of applications such as:

- Win32/Win64 applications (.NET, .COM, Visual C++ 6.0, Visual Basic 6.0),
- spreadsheets in Microsoft Office applications such as Excel and Access (VBA),
- web-based applications (ASP, PHP, VB script, Java),
- client applications (Java, VB),
- high-performance computing, computation servers (Fortran 77/90, C/C++),
- quant research tools: Matlab, Scilab.

1.2.2 Installation procedure

The installation procedure depends on the chosen API. Please refer to the *Getting started with Wall Risk Engine®* guide delivered with the API.

1.2.3 License

Each installation of the Wall Risk Engine® library requires a license which is generated from the expiration date and the MAC (or physical) address of the user's computer. To find this MAC address, you need to open a DOS command window, type "ipconfig /all" and read the MAC address corresponding to your network connexion.

1.3 Documentation

The available documentation for Wall Risk Engine® includes:

- The Wall Risk Engine® User Guide describes practical information for developers who use Wall Risk Engine®.
- The Wall Risk Engine® Quant Guide provides detailed information about the quant models.
- For each API, we provide a *Getting started* guide (pdf) driving you through your first experience with Wall Risk Engine®. You will find the detailed installation procedure as well as simple examples to get familiar with the functionalities and the API.

- A technical manual and integration examples for each language (Java, C/C++, Visual C++, VB/VBA) providing functions description, instructions and annotated sample programs.

1.4 Support

Any bug report or question regarding the use of Wall Risk Engine® should be sent to the consultant in charge of your project at Raise Partner.

2

How To's

We present hereafter examples explaining how to organize Wall Risk Engine® functionalities in order to build allocation, backtesting, stress-testing and simulation processes.

2.1 Portfolio allocation process

The figure 2.1 describes how to articulate Wall Risk Engine® functionalities to implement a portfolio allocation process, from the computation of historical returns to the ex-ante analysis of the optimal portfolio:

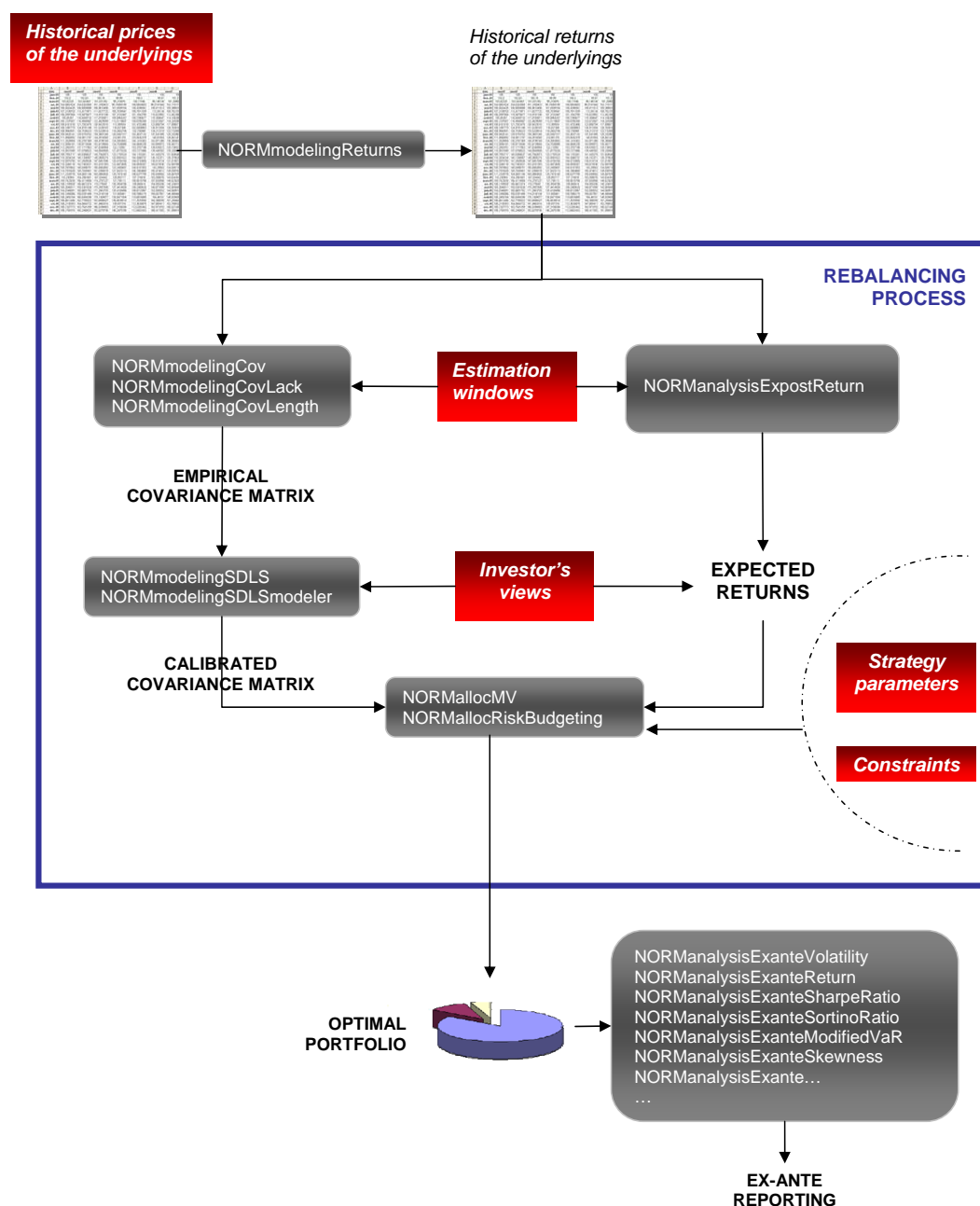
- Step 1: Computation of the arithmetic historical returns from the historical prices with the *NORMmodelingReturns* function
- Step 2: Construction of the risk model:
 - Computation of the historical estimation of the covariance matrix given the chosen estimation window, even if the historical dataset is incomplete (cf. Risk and Performance Modeling module).
 - Calibration of the covariance matrix with additionnal views (explicit or interval) on the volatilities or correlations.
- Step 3: Construction of the performance model:
 - Computation of the historical mean returns (historical trend approach) given the chosen estimation window.
 - This step can be completed or replaced by any in-house performance modeling process (based on a scoring approach for instance).
- Step 4: Computation of the optimal portfolio based on the risk and performance models, the chosen strategy (minimum volatility, risk budgeting...), the set of strategy parameters and the user-defined constraints.
- Step 5: Ex-ante analysis of the optimal portfolio with the ex-ante functions of the Risk and Performance module.

2.2 Back-testing of an investment strategy

The figure 2.2 describes how to implement a back-testing process to analyze an investment strategy on real past scenarios.

At each historical rebalancing date, the returns corresponding to the rolling estimation window are extracted and fed into the risk and performance models. Then the optimal portfolio at this date is computed, and the portfolio is left untouched until the next rebalancing date.

At the end of the back-test, the performances of the simulated portfolio are recomposed and compared to the underlying instruments (or to any other benchmark) via an ex-post risk and performance analysis.



**Historical prices
of the underlyings**

User's inputs

NORMmodelingReturns

NORM Asset Management® fonctionnalités

Figure 2.1: Portfolio rebalancing process with Wall Risk Engine® functions

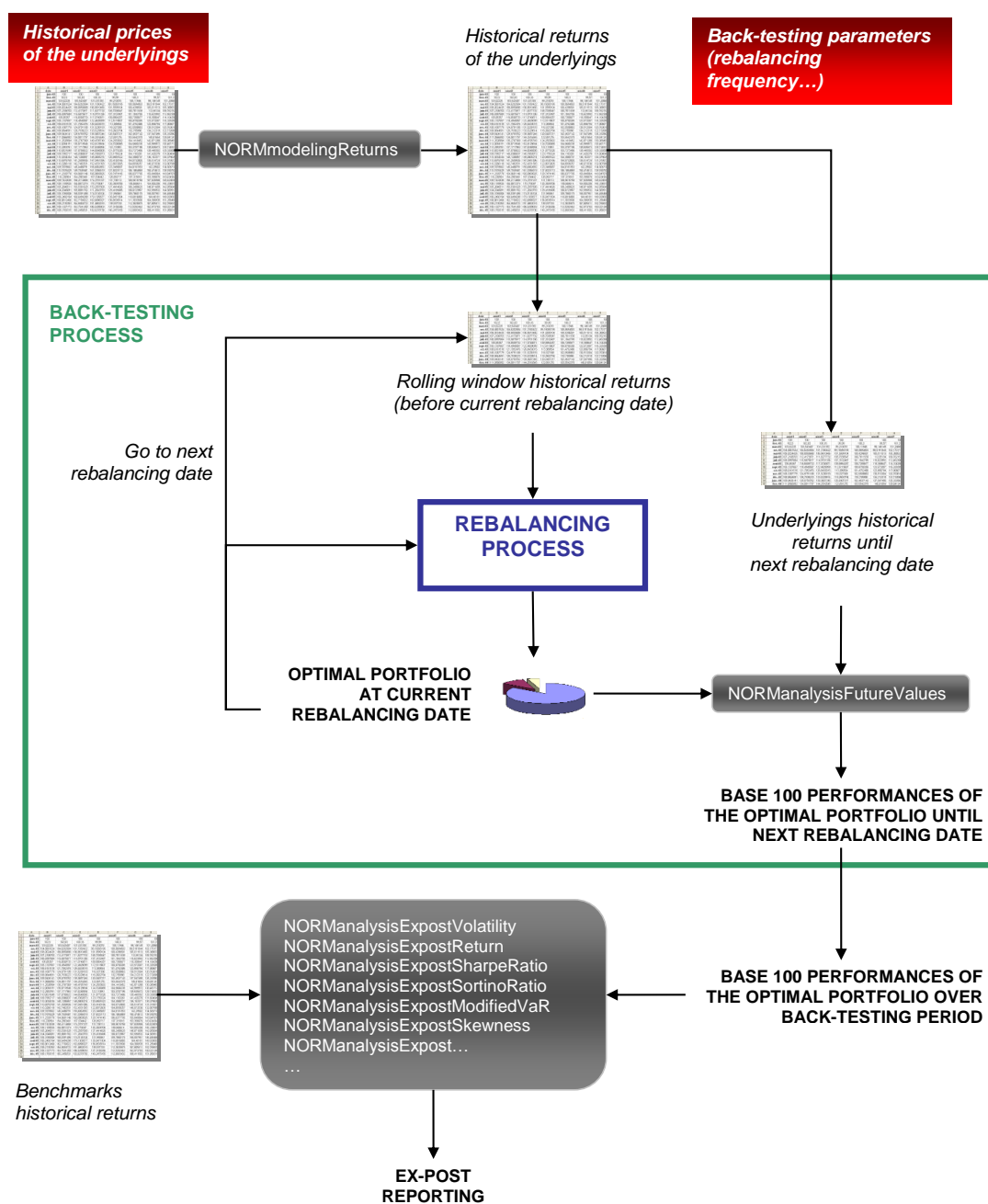


Figure 2.2: Back-testing process with Wall Risk Engine® functions

2.3 Simulating and analyzing a complex financial instrument (such as a structured product)

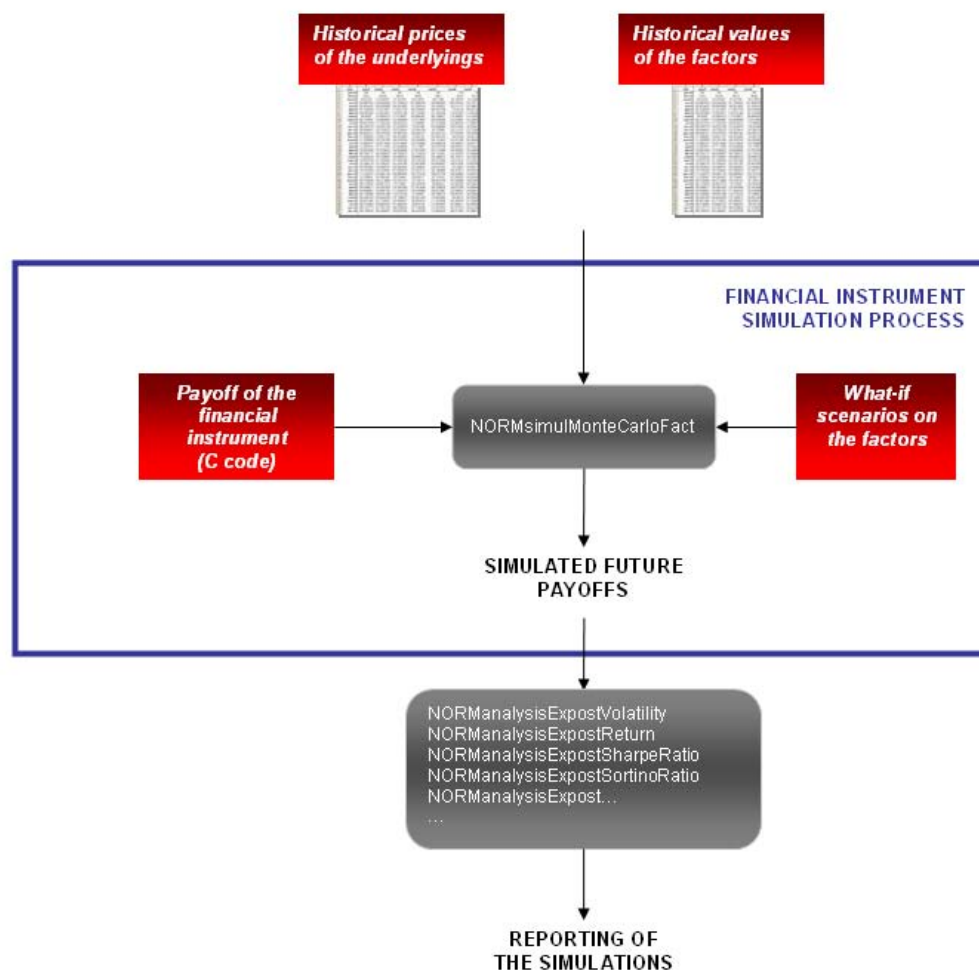


Figure 2.3: Financial instrument simulation process with Wall Risk Engine® functions

2.4 Building stress-testing scenarios for a portfolio

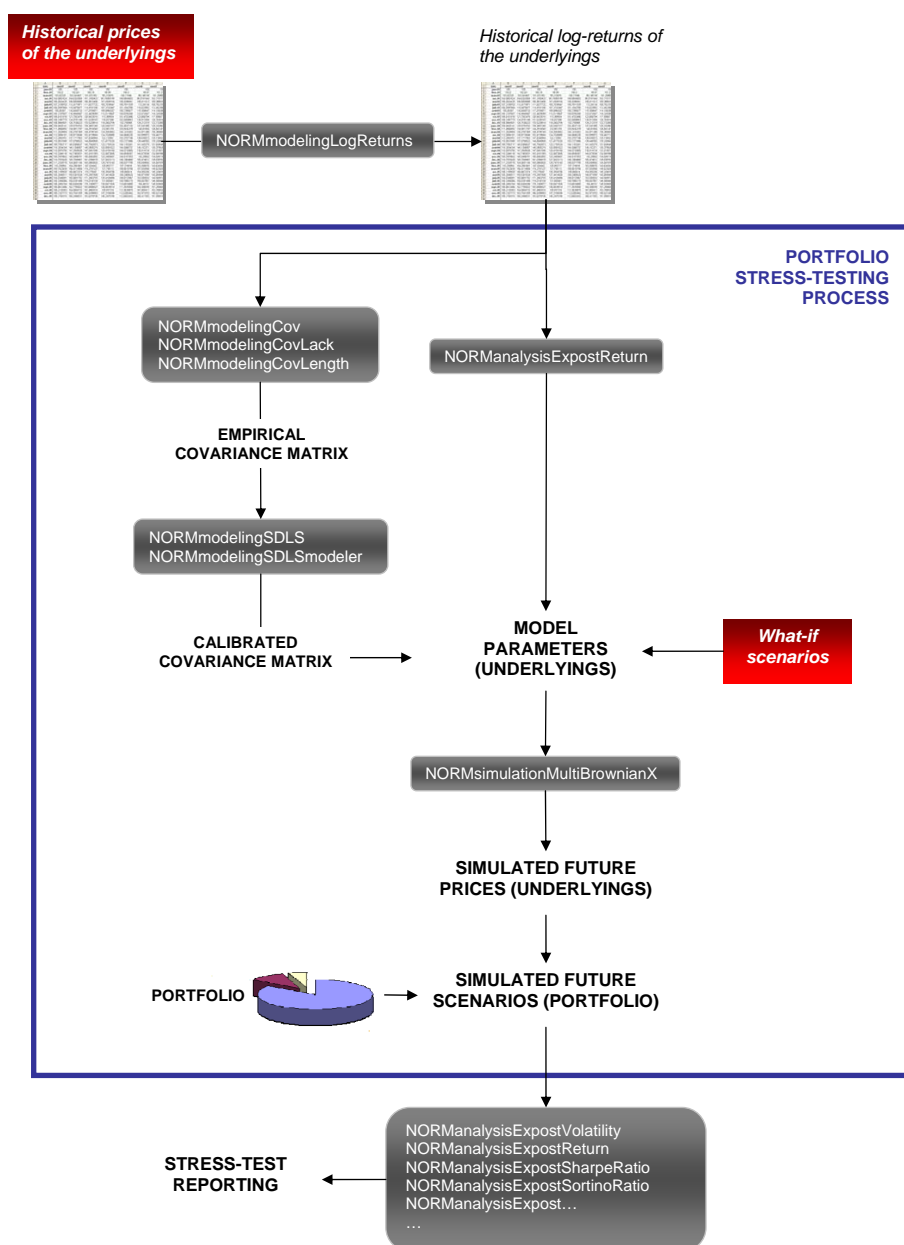


Figure 2.4: Portfolio stress-testing process with Wall Risk Engine® functions

Part I

Functions description

3

Troubleshooting

This chapter provides the user with instructions on how to access and interpret the error handling contained within the Wall Risk Engine® library. If these suggestions do not help evaluate specific difficulties, we suggest that the user review the “bug report” section (how to report a problem) and contact the Raise Partner support at support@raisepartner.com.

3.1 Common errors

We list in this section the most common programming errors when calling Wall Risk Engine® functions. These errors may cause the function to report a failure or they may lead to wrong results:

- wrong number of arguments,
- arguments in the wrong order,
- an argument of the wrong type (especially double and integer arguments of the wrong precision),
- wrong dimension for an array argument,
- bad value for an argument,
- insufficient space.

3.2 Bug report

All requests should be sent to the consultant in charge of your project at Raise Partner. The first questions we will ask are the following:

- the client’s name and/or reference code,
- the type of machine on which the function was run (e.g. Intel based),
- Operating system (e.g. Windows XP Professional),
- the program language used, e.g. Visual Basic 6.0,

- the name of the Wall Risk Engine® function, e.g. WREallocIT,
- the value of the function return code (res),
- the value of the diagnostic argument (info),
- if appropriate, a copy of the input file(s) and output file(s).

3.3 Error codes

Code	Description
0	Successful Termination
1i	Error in the <i>i</i> th argument size - computation performed. Ex. code = 102, the second argument has bad size.
2	Memory allocation problem - no computation performed.
3i	Illegal value(s) of the <i>i</i> th argument - no computation performed. Ex. code = 301, the first argument has bad size.
4*	License has expired or bad license - no computation performed. 41 or 42: license date expired. 43: MAC address not found. 44: MAC address access denied.
5	Numerical problem in computation - no computation performed. For further information see the diagnostic argument <i>info</i> < 0.
6	Warning - computation performed (but not optimal). For further information see the diagnostic argument <i>info</i> > 0.

3.3.1 Exit code *res*

Every function of Wall Risk Engine® returns an integer exit code that should be tested by the calling program. The exit code is to be interpretable as follows:

3.3.2 Diagnostic argument *info*

All routines have a diagnostic argument *info* that indicates the success or failure of the numerical computation (in case the error code is 5 or 6) for each function, as follows:

- *info* = 0 : successful termination, no problem occurred.
- *info* = * : computation problem defined for each routine - cf. table hereafter for the diagnostic argument interpretation.
 - If *info* > 0: Warning - computation performed (but not optimal)
 - If *info* < 0: Problem in computation - no computation performed

3.3.3 Arithmetic errors

Error Code	Warning	Description
-1		Division by zero - Divisor is zero and dividend is a finite nonzero number (ex. 10.8/0.0).
-2		Not enough data/value(s) for computation.
-3		Underflow - Operation produces a result that is too small to be represented as a normal number.
-4		Overflow - Operation produces a result that exceeds the range of exponent.
-5		Invalid operand - Operation with mathematically invalid operand.
6	x	Inexact - Operation produces a result that cannot be represented with finite precision.

3.3.4 Asset allocation errors

Error Code	Warning	Description
-100		The constraints $C_{inf} \leq w \leq C_{sup}$ or $C \leq b$ are incompatibles.
-101		Incompatible linear constraints.
-102		The probability confidence level α is not in $[0\%, 100\%]$.
-103		A quote/price value is too small (or zero).
-104		The variance/volatility is too small (or zero).
-105		The Tracking Error is too small (or zero).
106	x	The number of maximum iterations is reached without finding an optimal portfolio.
107	x	The TE/VaR constraint is too small The portfolio with minimum TE/VaR is computed.
-108		Covariance matrix must be definite positive (use matrix correction function).
-109		The input matrix (Risk Budgeting objective function) is not definite positive.
110	x	A risk budget constraint is too small (the dual solution of this constraint is equal to 1.E+15).
111	x	A risk budget constraint is too high, maximum number of iterations reached without saturation of this risk budget constraint (the dual solution of this constraint is equal to 0).
-112		A risk budget Index tracking constraint is negative, should be positive.
-113		Max. Sharpe ratio unattainable - No problem solution
-114		The risk-free rate is too large. No problem solution.
-115		min weight risk-free rate is larger than max weight risk-free rate. A non risk free rate allocation function should be used.
-116		Cardinality constraint unfeasible.

3.3.5 Optimization errors

Error Code	Warning	Description
1001	x	There are no admissible optimal points with these specified constraints.
-1002		No inferior bound supplied.
-1003		Degenerate point with infinite cycle.
-1004		Problem of bound, too large gap between two successive iterations.
-1005		Incorrect input(s) data.
-1006		Incompatibility of equality constraints.
-1009		Cardinality constraint not respected.
-1101		Error in the simulation/objective function (non-linear optimization).
-1102		An input parameter is badly initialized (non-linear optimization).
-1103		Quasi-Newton matrix is no definite positive (non-linear optimization).
1104	x	Maximum number of iterations reached without finding an admissible point (non-linear optimization).
1105	x	Maximum number of "simulator" call reached without finding an admissible point.
1106	x	Maximum precision reached without finding an admissible point (non-linear optimization).
-1107		Error in the Hessian matrix factorization (non-linear optimization).
-1108		The problem have no solution (info = 1106 with $dxmin < 1.E-15$)
-1109		At least one equality constraint unverified.
-1110		Problem with constraints, failed to pass checks
-1201		Problem in the dichotomy function.
1202	x	Maximum number of iterations reached without finding an admissible point (dichotomy).
1515	x	Unused Drawdown constraint (too high).
-1516	x	Drawdown constraint unfeasible.
5001	x	Absolute tolerance reached (SOCP).
5002	x	Relative tolerance reached (SOCP).
5003	x	Target value achieved (SOCP).
5004	x	Maximum number of iterations reached (SOCP).
5006	x	If feasible original problem is unbounded (SOCP).
-5001		Incorrect input(s) data (SOCP).
-5002		Error in the initialization of the size of the constraints (must be greater than 0) (SOCP).
-5003		Dual constraints no verified (SOCP).
-5004		Primal constraints not respected (SOCP).
-5005		Primal constraints no verified, unfeasible problem (SOCP).
-5006		The matrix A is not full ranked (SOCP).
-5007		Problem with lower/upper bounds (SOCP).

-5008	Target value unachievable (SOCP).
-5009	The constraint matrix not a symmetric matrix (SOCP).
-5010	The constraint matrix not a strictly positive matrix (SOCP).
-5011	None inverse matrix (SOCP).
-5014	The lambda parameter is negative (SOCP).
-5015	problem in the initialization of the primal (SOCP).
-5016	The linear primal constraints are not respected (SOCP).
-5019	Problem with the computation of pseudo-inverse. Constraints badly initialized (SOCP).
-5020	problem in the initialization of the dual (SOCP).
-5021	Problem ($\kappa > 0$) amplitude of the ellipsoid is strictly negative (SOCP).
-5022	Problem in the SOCP algorithm. (SOCP).

3.3.6 Matrix calibration errors

Error Code	Warning	Description
-1300		The input parameter α is too large, the constraint $\alpha \leq n \cdot \text{Trace}(C)$ is not verified (SDLS with trace constraint).
1301		The % of explain variance is too low.
1302		The % of explain variance is too large.
1310		No correction. The minimum eigenvalue is equal the maximum eigenvalue.
-2001		The input parameter α is not in $[0, 1]$, $X \geq \alpha \cdot \text{Id}$ (SDLS for correlation matrix).
-2003		Specified variance not in $[0, 1]$ (Kato correction).
-2004		Trace(X) is too small or zero (Kato correction).

3.3.7 Risk factor model errors

Error Code	Warning	Description
-4001		Bad index value (not equal to 11, 12, 13, 21, 22 or 23).
-4002		Number of point(s) used in iteration is too small or zero.
-4003		Incoherent number of tracking factor(s).
-4006		Numbers of iteration is too small or zero (Tracking Factor).
-4008		L2 norm is too small or zero (Tracking Factor).
4009	x	The covariance matrix Kato-structure is completely changing.

3.3.8 Simulation errors

Error Code	Warning	Description
-3001		The investment horizon is too small (or zero).
-3002		Initial price(s) is too small (or zero).
-3003		Number of simulation(s) is too small (or zero).
-3101		Bad process order (ARCH, GARCH).
-3102		Condition of process stationary not yields (ARCH, GARCH).

3.3.9 Pricing errors

Error Code	Warning	Description
-3201		First moment is negative
-3202		Second moment is negative
-3203		Underlying price is negative or null
-3204		Strike is negative or null
-3205		Time to maturity is negative
-3206		Barrier is negative or null
-3207		Initial value is negative (Brownian bridge)
-3208		Final value is negative or null (Brownian bridge)
-3209		Nominal is negative or null
-3210		Capital protection is negative or null
-3211		Yield to maturity is lower than -1 (formula: $rym = ((N - C0)/(CP * N))^{**}(T) - 1$)
-3212		Barrier is lower than financial level (ex mini future)
-3213		Price of the underlying is lower or equal to Barrier (ex mini future)
-3214		Barrier is greater than or equal to strike
-3215		Leverage is negative or null
-3216		Coupon is greater than 1
-3217		Number of observation dates has to be ≥ 1
-3218		Negative price got in the pricing process (ex. Exchangeable certificate, call at the emission)

3.3.10 Portfolio simulation errors

Error Code	Warning	Description
-3301		Threshold1-threshold2 is equal to zero in ConfidScore
-3302		Sum of underlying weights is null
-3303		Unrecognized type of product
3304	x	One or more than one product has experienced an error when pricing
-3305		Currency index is out of limit (must be \leq nbcncy and ≥ 1)
-3306		Time to maturity is negative or null
-3307		Bond last price St is negative or null
-3308		Nominal is negative or null (ex. Bonds)
-3309		One or more of bond historical prices are negative or null
-3310	x	Coefficient of diversification experienced a problem (possibly, correlations calculus)
-3311		All the instruments have experienced a problem when pricing, no calculation is done
3312	x	Error occurred while calculating VaR contributions
3313	x	Error occurred while calculating Performance contributions
-3314		Error occurred while calculating the VaR
-3315		Error occurred while calculating the confidence score
-3316		Error occurred while calculating the portfolio ex-post mean return
-3317		Error were occurred when adjusting bond returns (division by 0)
-3318		Product underlyings must be of the same currency (except straight certificate)
-3319		FX rate return of the product is less or equal than -1 (devision by 0)
-3320		Simulated FX is negative or null (devision by 0)
-3321		Product must have underlying currency index (see Ucrncies and Underlyings parameters)
-3322	x	Coefficient of diversification of the equi-weighted Ptf experienced a problem
-3323		Implicit volatility calculation problem
-3324		S and/or A are less then its threshold
-3325		NaN value detected in the outputs (maybe internal error or problem with data)
3326	x	
-3327		Market to theo problem

3.3.11 Data management errors

Error Code	Warning	Description
-8001		Last proxy date older (strictly inferior) than fist asset date.
-8002		First proxy date more recent (strictly superior) than last asset date.
-9001		All data are missing for a date.
-9003		No enough observed data.

3.3.12 Analysis errors

Error Code	Warning	Description
6000		Percent contribution cannot be provided (null risk or perf measure).

3.3.13 Data management errors

Error Code	Warning	Description
-301		Argument 1 has bad value (bad link to the source of data)

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