

Thierry Roncalli

Handbook of Financial Risk Management



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Preface

Teaching risk management in finance

This book is a handbook for students of Master's in finance, who want to learn risk management. It corresponds to the lecture notes of my course "*Risk Management & Financial Regulation*" at the University of Paris Saclay. This title highlights the role of financial regulation. Indeed, it appears that financial regulation is an important component to understand the practice of risk management in finance. This is particularly true in the banking sector, but it is also valid in other financial sectors. At first sight, it may be curious to teach for example the standards developed by the Basel Committee. They are freely available and any student may consult them. However, the regulation is so complex and the documentation produced is so abundant that students (but also professionals) may be lost when they want to have an overview on a specific topic or seek particular information. Therefore, I consider that the primary role of a course in risk management is to understand in general terms the financial regulation and be able to navigate between the various regulatory standards. This is all the more important that financial regulation is everywhere since the 2008 Global Financial Crisis (GFC). Today, most of the resources of a risk management department within a bank are dedicated to the regulation, and this is also the case of big projects. Understanding risk management requires them to know the regulation. Nevertheless, teaching risk management cannot be limited to the study of the regulation. Another important component of risk management is risk measurement. This requires having a statistical model for calculating the probability of a loss. A brief review shows that there are many risk models from the simplest to the most complicated because there are many types of risk and many risk factors. Moreover, the modeling of risk factors is not an easy task and requires making assumptions, and the complexity of a model can increase with the likelihood of these assumptions¹. Therefore, the second role of a course in risk management is to distinguish between the mathematical models of risk measurement and study those that are actually used by professionals. From an academic point of view, some models may appear to be outdated or old-fashioned. However, they can continue to be used by risk managers for many reasons: more robust, easier to calibrate, etc. For example, the most important risk measurement model is certainly the historical value-at-risk. This is why it is important to choose the right models to study. A handbook cannot be a comprehensive catalogue of risk management methods. But it must present the most frequently used models and the essential mathematical tools in order to help the Master student when he will be faced with reality and situations that will require a more complex modeling.

¹However, a complex model does not mean that the assumptions are more realistic.

About this book

These lecture notes are divided into two parts. After an introductory chapter presenting the main concepts of risk management and an overview of the financial regulation, the first part is dedicated to the risk management in the banking sector and is made up of seven chapters: market risk, credit risk, counterparty credit risk, operational risk, liquidity risk, asset liability management risk and systemic risk. I begin with the market risk, because it allows to introduce naturally the concept of risk factor, describe what a risk measure is and define the risk allocation approach. For each chapter, I present the corresponding regulatory framework and the risk management tools. I continue with five chapters that are mainly focused on the banking sector. However, even if these six chapters are dedicated to the banking sector, these materials also establish the basics of risk management in other financial sectors. They are the common language that is shared by all risk managers in finance. This first part ends with a eighth chapter on systemic risk and shadow banking system. In particular, this chapter supplements the introductory chapter and shows that the risk regulation culture has affected the other non-banking financial sectors such as asset management, insurance, pension funds and market infrastructure. The second part of these lecture notes develops the mathematical and statistical tools used in risk management. It contains seven chapters: model risk of exotic derivatives, statistical inference and model estimation, copula functions, extreme value theory, Monte Carlo simulation, stress testing methods and credit scoring models. Each chapter of these lecture notes is extensively illustrated by numerical examples and contains also tutorial exercises. Finally, a technical appendix completes the lecture notes and contains some important elements on numerical analysis.

The writing of these lecture notes started in April 2015 and is the result of twenty years of academic courses. When I began to teach risk management, a large part of my course was dedicated to statistical tools. Over the years, financial regulation became however increasingly important. I am convinced that risk management is now mainly driven by the regulation, not by the progress of the mathematical models. The writing of this book has benefited from the existing materials of my French book called “*La Gestion des Risques Financiers*”. Nevertheless, the structure of the two books is different, because my previous book only concerned market, credit and operational risk before Basel III. Some years ago, I decided to extend the course to other financial sectors, especially insurance, asset management and market infrastructure. In fact, it appears that the quantitative methods of risk management are the same across the different financial areas even if each sector presents its particular aspects. But they differ mainly by the regulation, not by the mathematical tools. The knowledge of the different regulations is not an easy task for students. However, it is necessary if one would like to understand what the role of risk management is in financial institutions in the present-day world. Moreover, reducing the practice of risk management to the assimilation of the regulation rules is not sufficient. The sound understanding of the financial products and the mathematical models are essential to know where the risks are. This is why some parts of this book can be difficult because risk management is today complex in finance. A companion book, which contains the solutions of the tutorial exercises, is available in order to facilitate learning and knowledge assimilation at the following internet web page:

<http://www.thierry-roncalli.com/RiskManagementBook.html>

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List of Symbols and Notations

Symbol Description

\times	Arithmetic multiplication	$\mathcal{B}(\alpha, \beta)$	Beta distribution with parameter α and β
\cdot	Scalar, vector and matrix multiplication	$\mathfrak{B}(\alpha, \beta)$	Beta function defined as $\int_0^1 t^{\alpha-1} (1-t)^{\beta-1} dt$
$*$	Convolution	$\mathfrak{B}(x; \alpha, \beta)$	Incomplete beta function $\int_0^x t^{\alpha-1} (1-t)^{\beta-1} dt$
\circ	Hadamard product: $(x \circ y)_i = x_i y_i$	\mathbf{c}	Coupon rate of the CDS premium leg
\otimes	Kronecker product $A \otimes B$	\mathbb{C} (or ρ)	Correlation matrix
$ \mathcal{E} $	Cardinality of the set \mathcal{E}	\mathfrak{C}	OTC contract
\prec	Concordance ordering	$\mathbf{C}(u_1, u_2)$	Copula function
$\langle x, x' \rangle$	Inner product of x and x'	\mathcal{C}	Set of copula functions
$\mathbf{1}$	Vector of ones	$\mathcal{C}(i)$	Mapping function
$\mathbb{1}\{\mathcal{A}\}$	The indicator function is equal to 1 if \mathcal{A} is true, 0 otherwise	$\check{\mathbf{C}}(u_1, u_2)$	Survival copula
$\mathbb{1}_{\mathcal{A}}\{x\}$	The characteristic function is equal to 1 if $x \in \mathcal{A}$, 0 otherwise	\mathbf{C}^-	Fréchet lower bound copula
$\mathbf{0}$	Vector of zeros	\mathbf{C}^\perp	Product copula
$(A_{i,j})$	Matrix A with entry $A_{i,j}$ in row i and column j	\mathbf{C}^+	Fréchet upper bound copula
A^{-1}	Inverse of the matrix A	\mathcal{C}_t	Price of the call option at time t
$A^{1/2}$	Square root of the matrix A	$C(t_m)$	Coupon paid at time t_m
A^\top	Transpose of the matrix A	$\mathbb{C}_n(\rho)$	Constant correlation matrix of dimension n with $\rho_{i,j} = \rho$
A^+	Moore-Penrose pseudo-inverse of the matrix A	$\text{CE}(t_0)$	Current exposure at time t_0
b	Vector of weights (b_1, \dots, b_n) for the benchmark b	$\text{cov}(X)$	Covariance of the random vector X
$B_t(T)$	Price of the zero-coupon bond at time t for the maturity T	$\chi^2(\nu)$	Chi-square distribution with ν degrees of freedom
$B(t, T)$	Alternative form of $B_t(T)$	D	Covariance matrix of idiosyncratic risks
$\mathcal{B}(p)$	Bernoulli distribution with parameter p	$\mathcal{D}(t)$	Liquidity duration of the new production
$\mathcal{B}(n, p)$	Binomial distribution with parameter n and p	$\mathcal{D}^*(t)$	Liquidity duration of the production stock
β_i	Beta of asset i with respect to portfolio w	$\mathbf{D}_k(x)$	Debye function
$\beta_i(w)$	Another notation for the symbol β_i	$\det(A)$	Determinant of the matrix A
$\beta(w b)$	Beta of portfolio w when the benchmark is b	$\text{diag } v$	Diagonal matrix with elements (v_1, \dots, v_n)
		Δ_t	Delta of the option at time t
		Δ_h	Difference operator $\Delta_h V_t = V_t - V_{t-h}$ with lag h

ΔCoVaR_i	Delta CoVaR of institution i	$\mathcal{G}(\alpha, \beta)$	Gamma distribution with parameters α and β
Δt_m	Time interval $t_m = t_{m-1}$	γ_1	Skewness
$\delta_x(y)$	Dirac delta function	γ_2	Excess kurtosis
\mathbf{e}_i	The value of the vector is 1 for the row i and 0 elsewhere	$\mathbf{\Gamma}_t$	Gamma of the option at time t
$\mathbb{E}[X]$	Mathematical expectation of the random variable X	$\Gamma(\alpha)$	Gamma function defined as $\int_0^\infty t^{\alpha-1} e^{-t} dt$
$\mathcal{E}(\lambda)$	Exponential probability distribution with parameter λ	$\gamma(\alpha, x)$	Lower incomplete gamma function defined as $\int_0^x t^{\alpha-1} e^{-t} dt$
$e(t)$	Potential future exposure at time t	$\Gamma(\alpha, x)$	Upper incomplete gamma function defined as $\int_x^\infty t^{\alpha-1} e^{-t} dt$
$\text{EE}(t)$	Expected exposure at time t	$\mathcal{G}\mathcal{E}\mathcal{V}(\mu, \sigma, \xi)$	GEV distribution with parameters μ, σ and ξ
$\text{EEE}(t)$	Effective expected exposure at time t	$\mathcal{G}\mathcal{P}\mathcal{D}(\sigma, \xi)$	Generalized Pareto distribution with parameters σ and ξ
$\text{EEPE}(0; t)$	Effective expected positive exposure for the time period $[0, t]$	h	Holding period
$\text{EnE}(t)$	Risk-neutral expected negative exposure at time t	\mathbf{h}	Kernel or smoothing parameter
$\text{EpE}(t)$	Risk-neutral expected positive exposure at time t	\mathbf{H}^-	Lower half-space
$\text{EPE}(0; t)$	Expected positive exposure for the time period $[0, t]$	\mathbf{H}^+	Upper half-space
$\text{ES}_\alpha(w)$	Expected shortfall of portfolio w at the confidence level α	\mathcal{H}	Hyperplane
$\exp(A)$	Exponential of the matrix A	$H(X)$	Shannon entropy of X
$f(x)$	Probability density function	$H(X, Y)$	Cross-entropy of X and Y
$f_{i:n}(x)$	Probability density function of the order statistic $X_{i:n}$	$H(Y X)$	Conditional entropy of Y with respect to X
$f_y(\lambda)$	Spectral density function of the stochastic process y_t	i	Asset (or component) i
$\mathbf{F}(x)$	Cumulative distribution function	I_n	Identity matrix of dimension n
$\mathbf{F}_{i:n}(x)$	Cumulative distribution function of the order statistic $X_{i:n}$	$I(X, Y)$	Mutual information of X and Y
$\mathbf{F}^{-1}(\alpha)$	Quantile function	$\mathcal{I}(\theta)$	Information matrix
\mathbf{F}^{n*}	n -fold convolution of the probability distribution \mathbf{F} with itself	$\mathcal{I}\mathcal{B}(x; \alpha, \beta)$	Regularized incomplete beta function
\mathcal{F}	Vector of risk factors $(\mathcal{F}_1, \dots, \mathcal{F}_m)$	$\mathcal{J}(\theta)$	Fisher information matrix
\mathcal{F}_j	Risk factor j	\mathcal{K}	Regulatory capital
\mathcal{F}_t	Filtration	$\mathcal{K}(x, x')$	Kernel function of x and x'
$f_t(T)$	Instantaneous forward rate at time t for the maturity T	$\ell(\theta)$	Log-likelihood function with θ the vector of parameters to estimate
$f(t, T)$	Alternative form of $f_t(T)$	ℓ_t	Log-likelihood function for the observation t
$F_t(T_1, T_2)$	Forward interest rate at time t for the period $[T_1, T_2]$	L	Lag operator: $Ly_t = y_{t-1}$
$F(t, T_1, T_2)$	Alternative form of $F_t(T_1, T_2)$	L or $L(w)$	Loss of portfolio w
$\mathfrak{F}(\nu_1, \nu_2)$	Fisher-Snedecor distribution with parameters ν_1 and ν_2	$\mathcal{L}(x; \lambda)$	Lagrange function, whose Lagrange multiplier is λ
$\mathcal{G}(p)$	Geometric distribution with parameter p	$\ln A$	Logarithm of the matrix A
$\mathcal{G}(\alpha)$	Standard gamma distribution with parameter α	$\mathcal{L}\mathcal{G}(\alpha, \beta)$	Log-gamma distribution with parameters α and β
		$\mathcal{L}\mathcal{L}(\alpha, \beta)$	Log-logistic distribution with parameters α and β
		$\mathcal{L}\mathcal{N}(\mu, \sigma^2)$	Log-normal distribution with parameters μ and σ
		λ	Parameter of exponential survival times
		$\lambda(t)$	Hazard function

λ^-	Lower tail dependence	$PE_\alpha(t)$	Peak exposure at time t with a confidence level α
λ^+	Upper tail dependence	$PV_t(\mathcal{L})$	Present value of the leg \mathcal{L}
$\mathbf{\Lambda}(x)$	Gumbel distribution	Π or $\Pi(w)$	P&L of the portfolio w
$\Lambda(t)$	Markov generator	$\phi(x)$	Probability density function of the standardized normal distribution
MDA (\mathbf{G})	Maximum domain of attraction of the extreme value distribution \mathbf{G}	$\phi_2(x_1, x_2; \rho)$	Probability density function of the bivariate normal distribution with correlation ρ
MES_i	Marginal expected shortfall of institution i	$\phi_n(x; \Sigma)$	Probability density function of the multivariate normal distribution with covariance matrix Σ
$MPE_\alpha(0; t)$	Maximum peak exposure for the time period $[0, t]$ with a confidence level α	$\Phi(x)$	Cumulative density function of the standardized normal distribution
\mathcal{MR}_i	Marginal risk of asset i	$\Phi^{-1}(\alpha)$	Inverse of the cdf of the standardized normal distribution
MtM	Mark-to-market of the portfolio	$\Phi_2(x_1, x_2; \rho)$	Cumulative density function of the bivariate normal distribution with correlation ρ
μ	Vector of expected returns (μ_1, \dots, μ_n)	$\Phi_n(x; \Sigma)$	Cumulative density function of the multivariate normal distribution with covariance matrix Σ
μ_i	Expected return of asset i	$\Phi_\alpha(x)$	Fréchet distribution
μ_m	Expected return of the market portfolio	$\Psi_\alpha(x)$	Weibull distribution
$\hat{\mu}$	Empirical mean	$\varphi_X(t)$	Characteristic function of the random variable X
$\mu(w)$	Expected return of portfolio w	$q_\alpha(n_S)$	Integer part of αn_S
$\mu(X)$	Mean of the random vector X	$q_{\bar{\alpha}}(n_S)$	Integer part of $(1 - \alpha) n_S$
$\mu_m(X)$	m -th centered moment of the random vector X	\mathbb{Q}	Risk-neutral probability measure
$\mu'_m(X)$	m -th moment of the random vector X	\mathbb{Q}_T	Forward probability measure
$\mathcal{N}(\mu, \sigma^2)$	Normal distribution with mean μ and standard deviation σ	$\mathfrak{R}(t)$	Rating of the entity at time t
$\mathcal{N}(\mu, \Sigma)$	Multivariate normal distribution with mean μ and covariance matrix Σ	r	Return of the risk-free asset
n_S	Number of scenarios or simulations	R	Vector of asset returns (R_1, \dots, R_n)
$N(t)$	Poisson counting process for the time interval $[0, t]$	R_i	Return of asset i
$N(t_1; t_2)$	Poisson counting process for the time interval $[t_1, t_2]$	$R_{i,t}$	Return of asset i at time t
$\mathcal{NB}(r, p)$	Negative binomial distribution with parameters r and p	$R_{m,t}$	Return of the market portfolio at time t
Ω	Covariance matrix of risk factors	$R(w)$	Return of portfolio w
P	Markov transition matrix	$\mathcal{R}(w)$	Risk measure of portfolio w
\mathbb{P}	Historical probability measure	$\mathcal{R}(L)$	Risk measure of loss L
$P(\Sigma)$	Cholesky decomposition of Σ	$\mathcal{R}(\Pi)$	Risk measure of P&L Π
$\mathcal{P}(\lambda)$	Poisson distribution with parameter λ	$R_t(T)$	Zero-coupon rate at time t for the maturity T
$p(k)$	Probability mass function of an integer-valued random variable	\mathcal{RC}_i	Risk contribution of asset i
\mathcal{P}_t	Price of the put option at time t	\mathcal{RC}_i^*	Relative risk contribution of asset i
$\mathcal{P}(\alpha, x_-)$	Pareto distribution with parameters α and x_-	\mathcal{R}	Recovery rate
$\mathcal{P}(\alpha, \theta)$	Pareto distribution with parameters α and θ	RPV ₀₁	Risky PV01

ρ (or \mathbb{C})	Correlation matrix of asset returns	$\mathbf{t}_n(x; \Sigma, \nu)$	Probability density function of the multivariate t distribution with parameters Σ and ν
$\rho_{i,j}$	Correlation between asset returns i and j	$\mathbf{t}_2(x_1, x_2; \rho, \nu)$	Probability density function of the bivariate t distribution with parameters ρ and ν
$\rho(x, y)$	Correlation between portfolios x and y	T	Maturity date
s	Credit spread	$\mathbf{T}(x; \nu)$	Cumulative density function of the univariate t distribution with number of degrees of freedom ν
$\mathbf{S}(x)$	Survival function	$\mathbf{T}^{-1}(\alpha; \nu)$	Inverse of the cdf of the Student's t distribution with ν the number of degrees of freedom
\mathbb{S}	Stress scenario	$\mathbf{T}_n(x; \Sigma, \nu)$	Cumulative density function of the multivariate t distribution with parameters Σ and ν
S_t	Price of the underlying asset at time t	$\mathbf{T}_2(x_1, x_2; \rho, \nu)$	Cumulative density function of the bivariate t distribution with parameters ρ and ν
$\mathbf{S}_t(T)$	Survival function of T at time t	\mathcal{T}	return period
$\mathbf{S}(t, u)$	Amortization function of the new production	$\text{tr}(A)$	Trace of the matrix A
$\mathbf{S}^*(t, u)$	Amortization function of the production stock	θ	Vector of parameters
$\mathcal{S}(y_t)$	Stationary form of the process y_t	$\hat{\theta}$	Estimator of θ
SES_i	Systemic expected shortfall of institution i	Θ_t	Theta of the option at time t
$\mathcal{SN}(\xi, \Omega, \eta)$	Skew normal distribution	τ	Default time
SRISK_i	Systemic risk contribution of institution i	τ	Time to maturity $T - t$
$\mathcal{ST}(\xi, \Omega, \eta, \nu)$	Skew t distribution	$\mathcal{U}_{[a,b]}$	Uniform distribution between a and b
$\text{SV}_t(\mathcal{L})$	Stochastic discounted value of the leg \mathcal{L}	$\text{var}(X)$	Variance of the random variable X
Σ	Covariance matrix	$\text{VaR}_\alpha(w)$	Value-at-risk of portfolio w at the confidence level α
$\hat{\Sigma}$	Empirical covariance matrix	\mathbf{v}_t	Vega of the option t
σ_i	Volatility of asset i	w	Vector of weights (w_1, \dots, w_n) for portfolio w
σ_m	Volatility of the market portfolio	w_i	Weight of asset i in portfolio w
$\tilde{\sigma}_i$	Idiosyncratic volatility of asset i	$W(t)$	Wiener process
$\hat{\sigma}$	Empirical volatility	X	Random variable
$\sigma(w)$	Volatility of portfolio w	x^+	Maximum value between x and 0
$\sigma(X)$	Standard deviation of the random variable X	$X_{i:n}$	i^{th} order statistic of a sample of size n
t_ν	Student's t distribution with ν degrees of freedom	y_t	Discrete-time stochastic process
$t_n(\Sigma, \nu)$	Multivariate Student's t distribution with ν degrees of freedom and covariance matrix Σ	\mathbf{y}	Yield to maturity
$\mathbf{t}(x; \nu)$	Probability density function of the univariate t distribution with number of degrees of freedom ν		

Abbreviations

ABCP	Asset-backed commercial paper	AFME	Association for Financial Markets in Europe
ABS	Asset-backed security	AFS	Available-for-sale
ADF	Augmented Dickey-Fuller unit root test	AIC	Akaike information criterion
ADV	Average daily volume	AIFMD	Alternative investment fund managers directive
AER	Annual equivalent rate		

AIRB	Advanced internal ratings-based approach (credit risk)	CCR	Counterparty credit risk
ALCO	ALM committee	CDF	Cumulative distribution function
ALM	Asset liability management	CDO	Collateralized debt obligation
AM-CVA	Advanced method (credit valuation adjustment)	CDS	Credit default swap
AMA	Advanced measurement approaches (operational risk)	CDT	Credit default tranche
AMF	Autorité des Marchés Financiers	CDX	Credit default index
AMLF	ABCP money market mutual fund liquidity facility	CE	Current exposure
AR	Autoregressive process	CEM	Current exposure method (CCR)
ARCH	Autoregressive conditional heteroskedasticity process	CET1	Common equity tier 1
ARMA	Autoregressive moving average process	CFH	Cash flow hedge
AT1	Additional tier 1	CFI	Captive financial institution
ATM	At-the-money (option)	CFO	Chief financial officer
BA-CVA	Basic approach (credit valuation adjustment)	CGFS	Committee on the Global Financial System
BAC	Binary asset-or-nothing call option	CIR	Cox-Ingersoll-Ross process
BaFin	Bundesanstalt für Finanzdienstleistungsaufsicht	CISC	Constant inter-sector correlation model
BAP	Binary asset-or-nothing put option	CLO	Collateralized loan obligation
BCBS	Basel Committee on Banking Supervision	CMBS	Commercial mortgage-backed security
BCC	Binary cash-or-nothing call option	CMO	Collateralized mortgage obligation
BCP	Binary cash-or-nothing put option	CoVaR	Conditional value-at-risk
BCVA	Bilateral CVA	CP	Consultation paper
BD	Broker-dealer	CPM	Constant payment mortgage
BFGS	Broyden-Fletcher-Goldfarb-Shanno algorithm	CPR	Conditional prepayment rate
BGD	Batch gradient descent	CRA	Credit rating agency
BIA	Basic indicator approach (operational risk)	CRD	Capital requirements directive
BIS	Bank for International Settlement	CRM	Comprehensive risk measure
BLUE	Best linear unbiased estimator	CRO	Chief risk officer
BoJ	Bank of Japan	CRR	Capital requirements regulation
BS	Black-Scholes model	CSRBB	Credit spread risk in the banking book
BSM	Basic structural model	CVA	Credit valuation adjustment
BUE	Best unbiased estimator	DF	Dickey-Fuller unit root test
CAD	Capital adequacy directive	DFAST	Dodd-Frank Act stress testing
CAM	Constant amortization mortgage	DFP	Davidon-Fletcher-Powell algorithm
CaR	Capital-at-risk	DFT	Discrete Fourier transform
CB	Conservation buffer (CET1)	DGAP	Duration gap
CBO	Collateralized bond obligation	DIC	Down-and-in call option
CCB	Countercyclical capital buffer (CET1)	DIP	Down-and-in put option
CCF	Credit conversion factor	DOC	Down-and-out call option
CCP	Central counterparty clearing house	DOP	Down-and-out put option
		DP	Dynamic programming
		DRC	Default risk capital
		DV01	Dollar value of a one basis point decrease in interest rates
		DVA	Debit valuation adjustment
		EAD	Exposure at default
		EaR	Earnings-at-risk
		EAR	Effective annual rate
		EBA	European Banking Authority

ECB	European Central Bank	FVTPL	Fair value through profit and loss
ECM	Error correction model	FWN	Fractional white noise
ECRA	External credit risk assessment	GAAP	Generally accepted accounting principles (US)
EE	Expected exposure	GARCH	Generalized autoregressive conditional heteroskedasticity process
EEE	Effective expected exposure	GBM	Geometric Brownian motion
EEPE	Effective expected positive exposure	GCV	Generalized cross-validation
EL	Expected loss	GEV	Generalized extreme value distribution
EMIR	European market infrastructure regulation	GFC	Global Financial Crisis (2008)
ENE	Expected negative exposure	GMM	Generalized method of moments
EPE	Expected positive exposure	GMM	Gaussian mixture model
ERBA	External ratings-based approach	GNMA	Ginnie Mae
ES	Expected shortfall	GPD	Generalized Pareto distribution
ESMA	European Securities and Markets Authority	HELOC	Home equity line of credit
ETF	Exchange traded fund	HF	Hedge fund
EV	Economic value	HFT	Held-for-trading
EVaR	Economic value-at-risk	HJM	Heath-Jarrow-Morton model
EVE	Economic value of equity	HLA	Higher loss absorbency
EVT	Extreme value theory	HPP	Homogeneous Poisson process
FASB	Financial Accounting Standards Board	HQLA	High-quality liquid assets
FBA	Fall-back approach	HTM	Held-to-maturity
FC	Finance company	HY	High yield entity
FDIC	Federal Deposit Insurance Corporation	IAIS	International Association of Insurance Supervisors
FDML	Frequency domain maximum likelihood	IAS	International accounting standard
FFT	Fast Fourier transform	ICAAP	Internal capital adequacy assessment process
FHFA	Federal Housing Finance Agency	ICP	Insurance Core Principles
FICO	Fair Isaac Corporation score	ICPF	Insurance companies and pension funds
FIR	Finite impulse response filter	IF	Investment fund
FIRB	Foundation internal ratings-based approach (credit risk)	IFG	Infinitely fine-grained portfolio
FNMA	Fannie Mae	IFRS	International financial reporting standard
FRA	Forward rate agreement	IG	Investment grade entity
FRB	Board of Governors of the Federal Reserve System	ILAAP	Internal liquidity adequacy assessment process
FRTB	Fundamental review of the trading book	IMA	Internal model-based approach (market risk)
FSAP	Financial sector assessment program	IMCC	Internally modelled capital charge (Basel III)
FSB	Financial Stability Board	IMF	International Monetary Fund
FtD	First-to-default swap	IMM	Internal model method (counterparty credit risk)
FTP	Funds transfer pricing	IOSCO	International Organization of Securities Commissions
FV	Fair value	IPP	Integration by parts
FVA	Founding valuation adjustment	IRB	Internal ratings-based approach (credit risk)
FVH	Fair value hedge		
FVOCI	Fair value through other comprehensive income		

IRRBB	Interest rate risk in the banking book	MM	Method of moments
IRC	Incremental risk charge	MMF	Money market fund
IRS	Interest rate swap	MPE	Maximum peak exposure
ISDA	International Swaps and Derivatives Association	MPOR	Margin period of risk
ITM	In-the-money (option)	MPP	Mixed Poisson process
JTD	Jump-to-default	MSMVE	Min-stable multivariate exponential distribution
KF	Kalman filter	MtM	Mark-to-market
KIC	Knock-in call option	MUNFI	Monitoring universe of non-bank financial intermediation
KIP	Knock-in put option	NHPP	Non-homogeneous Poisson process
KOC	Knock-out call option	NIH	Net investment hedge
KOP	Knock-out put option	NII	Net interest income
KPSS	Kwiatkowski-Phillips-Schmidt-Shin stationary test	NIM	Net interest margin
KRI	Key risk indicator	NIS	Net interest spread
L&R	Loans and receivables	NMD	Non-maturity deposit
LAD	Least absolute deviation estimator	NMF	Non-negative matrix factorization
LCG	Linear congruential generator	NN	Neural network
LCR	Liquidity coverage ratio	NOW	Negotiable order of withdrawal
LDA	Loss distribution approach (operational risk)	NQD	Negative quadrant dependence
LDA	Linear discriminant analysis	NSFR	Net stable funding ratio
LDCE	Loss data collection exercise	OCC	Office of the Comptroller of the Currency
LEE	Loan equivalent exposure	ODE	Ordinary differential equation
LGD	Loss given default	OFI	Other financial intermediary
LL	Local level model	OLS	Ordinary least squares
LLT	Local linear trend model	ORSA	Own risk and solvency assessment
LMM	Libor market model	OTC	Over-the-counter
LTA	Look-through approach	OTM	Out-of-the-money (option)
LtD	Last-to-default swap	OTS	Office of Thrift Supervision
LTI	Linear time-invariant filter	OU	Ornstein-Uhlenbeck process
LTV	Loan-to-value ratio	P&L	Profit and loss
M	Effective maturity	PCA	Principal component analysis
MA	Moving average process	PD	Probability of default
MBS	Mortgage-backed security	PDE	Partial differential equation
MC	Monte Carlo	PDF	Probability density function
MCMC	Markov chain Monte Carlo	PE	Peak exposure
MCR	Minimum capital requirement	PFE	Potential future exposure
MDA	Maximum domain of attraction	PLA	Profit and loss attribution (Basel III)
MDB	Multilateral development bank	PMF	Probability mass function
MES	Marginal expected shortfall	POT	Peak over threshold
MEV	Multivariate extreme value	PP	Phillips-Perron unit root test
MF	Mutual fund	PQD	Positive quadrant dependence
MGD	Mini-batch gradient descent	PRESS	Predicted residual error sum of squares
MiFID	Markets in financial instruments directive	PSE	Public sector entity
MiFIR	Markets in financial instruments regulation	PV01	Present value of one bp
ML	Maximum likelihood	QDA	Quadratic discriminant analysis
MLE	Maximum likelihood estimator	QIS	Quantitative impact study
		QMC	Quasi-Monte Carlo

QP	Quadratic programming	SN	Skew normal distribution
RBC	Risk-based capital (US insurance)	SPV	Special purpose vehicle
REIT	Real estate investment trust	SQP	Sequential quadratic programming
RFET	Risk factor eligibility test (Basel III)	SRC	Specific risk charge
RLS	Recursive least squares	SREP	Supervisory review and evaluation process
RMBS	Residential mortgage-backed security	SRISK	Systemic risk contribution
ROE	Return-on-equity	SRP	Supervisory review process
RRAO	Residual risk add-on	SSFA	Simplified supervisory formula approach
RW	Risk weight	SSM	Single supervisory mechanism
RWA	Risk-weighted assets	SSM	State space model
RWR	Right way risk	ST	Skew t distribution
SA	Standardized approach (credit risk)	STC	Simple, transparent and comparable (securitization)
SA-CCR	Standardized approach (counterparty credit risk)	StD	Second-to-default swap
SA-CVA	Standardized approach (credit valuation adjustment)	SVaR	Stressed value-at-risk
SA-TB	Standardized approach for the trading book (market risk)	SVI	Stochastic volatility inspired
SABR	Stochastic alpha-beta-rho model	SVM	Support vector machine
SBE	Shadow banking entity	T1	Tier 1
SBS	Shadow banking system	T2	Tier 2
SCR	Solvency capital requirement	TC	Trust company
SCRA	Standardized credit risk approach	TDML	Time domain maximum likelihood
SDE	Stochastic differential equation	TDRR	Term deposit redemption ratio
SES	Systemic expected shortfall	TLAC	Total loss absorbing capacity
SFT	Securities financing transaction	TSA	The standardized approach (operational risk)
SFV	Structured finance vehicle	UCITS	Undertakings for collective investment in transferable securities (directive)
SGD	Stochastic gradient descent	UCVA	Unilateral CVA
SIFI	Systemically important financial institution	UDVA	Unilateral DVA
SIFMA	Securities Industry and Financial Markets Association	UL	Unexpected loss
SIR	Sampling importance resampling	UIC	Up-and-in call option
SIS	Sequential importance sampling	UIP	Up-and-in put option
SIV	Structured investment vehicle	UOC	Up-and-out call option
SLA	Single loss approximation	UOP	Up-and-out put option
SLN	Shifted log-normal model	UVM	Uncertain volatility model
SM-CCR	Standardized method (counterparty credit risk)	VaR	Value-at-risk
SM-CVA	Standardized method (credit valuation adjustment)	VAR	Vector autoregressive process
SMC	Sequential Monte Carlo	VARMA	Vector autoregressive moving average process
SME	Small and medium-sized enterprises	VECM	Vector error correction model
SMM	Standardized measurement method (market risk)	WAL	Weighted average life
SMM	Swap market model	WLS	Weighted least squares
		WWR	Wrong way risk
		XO	Crossover (or sub-investment grade) entity

Other scientific conventions

YYYY-MM-DD	We use the international standard date notation where YYYY is the year in the usual Gregorian calendar, MM is the month of the year between 01 (January) and 12 (December), and DD is the day of the month between 01 and 31.
USD (or \$)	US dollar
EUR (or €)	Euro
KUSD	One thousand dollars
\$1 mn/bn/tn	One million/billion/trillion dollars
bp	Basis point or 0.01%



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