MULTI-ASSET PORTFOLIO SIMULATION (MAPS)

TECHNICAL FIELD

[0001] This disclosure relates generally to financial products, methods and systems, and more particularly to systems and methods for collateralizing risk of financial products.

BACKGROUND

[0002] Conventional clearinghouses collect collateral in the form of an "initial margin" ("IM") to offset counterparty credit risk (i.e., risk associated with having to liquidate a position if one counterparty of a transaction defaults). In order to determine how much IM to collect, conventional systems utilize a linear analysis approach for modeling the risk. This approach, however, is designed for financial products, such as equities and futures, that are themselves linear in nature (i.e., the products have a linear profit/loss scale of 1:1). As a result, it is not well suited for more complex financial products, such as options, volatile commodities (e.g., power), spread contracts, non-linear exotic products or any other financial products having non-linear profit / loss scales. In the case of options, for example, the underlying product and the option itself moves in a non-linear fashion, thereby resulting in an exponential profit / loss scale. Thus, subjecting options (or any other complex, non-linear financial products) to a linear analysis will inevitably lead to inaccurate IM determinations.

[0003] Moreover, conventional systems fail to consider diversification or correlations between financial products in a portfolio when determining an IM for the entire portfolio. Instead, conventional systems simply analyze each product in a portfolio individually, with no consideration for diversification of product correlations.

[0004] Accordingly, there is a need for a system and method that efficiently and accurately calculates IM for both linear and non-linear products, and that considers diversification and product correlations when determining IM for a portfolio of products.

SUMMARY

[0005] The present disclosure relates to systems and methods of collateralizing counterparty credit risk for at least one financial product or financial portfolio comprising mapping at least one financial product to at least one risk factor, executing a risk factor simulation process comprising a filtered historical simulation process, generating product or portfolio profit and loss values and determining an initial margin for the financial product or portfolio.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The foregoing summary and following detailed description may be better understood when read in conjunction with the appended drawings. Exemplary embodiments are shown in the drawings, however, it should be understood that the exemplary embodiments are not limited to the specific methods and instrumentalities depicted therein. In the drawings:

[0007] Fig. 1 shows an exemplary risk engine architecture.

[0008] Fig. 2 shows an exemplary diagram showing various data elements and functions of an exemplary MAPS system according to the present disclosure.

[0009] Fig. 3 shows an exemplary implied volatility to delta surface graph of an exemplary MAPS system according to the present disclosure.

[0010] Fig. 4 shows a cross-section of the exemplary implied volatility of an exemplary MAPS system according to the present disclosure.

[0011] Fig. 5 shows an exemplary implied volatility data flow of an exemplary MAPS system according to the present disclosure.

[0012] Fig. 6 shows a graphical representation of an exemplary transformation of delta-to-strike of an exemplary MAPS system according to the present disclosure.

[0013] Fig. 7 shows an exemplary fixed time series of an exemplary MAPS system according to the present disclosure.

[0014] Fig. 8 shows a chart of the differences between an exemplary relative and fixed expiry data series of an exemplary MAPS system according to the present disclosure.

[0015] Fig. 9 shows a chart of an exemplary fixed expiry dataset of an exemplary MAPS system according to the present disclosure.

[0016] Fig. 10 shows an exemplary clearinghouse account hierarchy of an exemplary MAPS system according to the present disclosure.

[0017] Fig. 11 shows another exemplary clearinghouse account hierarchy of an exemplary MAPS system according to the present disclosure.

[0018] Fig. 12 shows another exemplary clearinghouse account hierarchy of an exemplary MAPS system according to the present disclosure.

[0019] Fig. 13 shows another exemplary clearinghouse account hierarchy of an exemplary MAPS system according to the present disclosure.

[0020] Fig. 14 shows another exemplary clearinghouse account hierarchy of an exemplary MAPS system according to the present disclosure.

[0021] Fig. 15 shows an exemplary hierarchy of a customer's account portfolio of an exemplary MAPS system according to the present disclosure.

DETAILED DESCRIPTION

Introduction

[0022] The present disclosure relates generally to systems and methods for efficiently and accurately collateralizing counterparty credit risk. Notably, the systems and methods described herein are effective for use in connection with all types of financial products (e.g., linear and non-linear, complex), and with portfolios of financial products, whether fully or partially diversified.

[0023] As indicated above, conventional systems utilize a linear analysis approach for modeling risk of all types of financial products, including those financial products that are not themselves linear in nature. Moreover, conventional systems fail to consider diversification or correlations between financial products in a portfolio when determining an initial margin ("IM") for the entire portfolio. As will be appreciated, diversification and product correlations within a portfolio can offset some of the overall risk of the portfolio, thereby reducing the IM that needs to be collected.

[0024] The systems and methods described herein address the foregoing deficiencies (as well as others) by providing new systems and methods that efficiently and accurately calculate IMs for both linear and non-linear products, and that consider diversification and product correlations when determining IM for a portfolio of products.

[0025] In one aspect, the present disclosure relates to a novel Multi-Asset Portfolio Simulation (MAPS) system and method. MAPS, in one embodiment, utilizes a unique technique for determining IM that includes (without limitation) decomposing products (e.g., complex non-linear products) into their respective individual components, and then mathematically modeling the components to assess a risk of each component. For purposes of this disclosure,

"decomposing" may be considered a mapping of a particular financial product to the components or factors that drive that product's profitability (or loss). This mapping may include, for example, identifying those components or factors that drive a financial product's profitability (or loss). A "component" or "factor" (or "risk factor") may therefore refer to a value, rate, yield, underlying product or any other parameter or object that may affect, negatively or positively, a financial product's profitability.

[0026] Once the components (or factors) are mathematically modeled, a second mapping (in the reverse direction) may be executed in which the components (or factors) are then reassembled. In the context of this disclosure, "reassembling" components of a financial product may be considered an aggregation of the results of the modeling procedure summarized above.

[0027] After the components (or factors) of the financial product are reassembled, the entire product may be processed through a filtered historical simulation (FHS) process to determine an IM (or a 'margin rate') for the financial product.

[0028] For purposes of this disclosure, the term "product" or "financial product" should be broadly construed to comprise any type of financial instrument including, without limitation, commodities, derivatives, shares, bonds, and currencies. Derivatives, for example, should also be broadly construed to comprise (without limitation) any type of options, caps, floors, collars, structured debt obligations and deposits, swaps, futures, forwards, and various combinations thereof.

[0029] A similar approach may be taken for a portfolio of financial products (i.e., a financial portfolio). Indeed, a financial portfolio may be broken down into its individual financial products, and the individual financial products may each be decomposed into their respective components (or factors). Each component (or factor) may then be mathematically modeled to

determine a risk associated with each component (or factor), reassembled to its respective financial product, and the financial products may then be reassembled to form the financial portfolio. The entire portfolio may then be processed through an FHS process to determine an overall margin rate for the financial portfolio as a whole.

[0030] In addition, any correlations between the financial products or pertinent product hierarchy within the financial portfolio may be considered and taken into account to determine an IM (or a margin rate) for the financial portfolio. This may be accomplished, for example, by identifying implicit and explicit relationships between all financial products in the financial portfolio, and then accounting (e.g., offsetting risk) for the relationships where appropriate.

[0031] As will be evident from the foregoing, the present disclosure relates to a top-down approach for determining IM that determines and offsets product risk where appropriate. As a result, the systems and methods described herein are able to provide a greater level of precision and accuracy when determining IM. In addition, this top-down approach facilitates the ability to compute an IM on a fully diversified level or at any desired percentage level.

[0032] Systems and methods of the present disclosure may include and/or be implemented by one or more computers or computing devices. For purposes of this disclosure, a "computer" or "computing device" (these terms may be used interchangeably) may be any programmable machine capable of performing arithmetic and/or logical operations. In some embodiments, computers may comprise processors, memories, data storage devices, and/or other commonly known or novel components. These components may be connected physically or through network or wireless links. Computers may also comprise software which may direct the operations of the aforementioned components.

[0033] Exemplary (non-limiting) examples of computers include any type of server (e.g., network server), a processor, a microprocessor, a personal computer (PC) (e.g., a laptop computer), a palm PC, a desktop computer, a workstation computer, a tablet, a mainframe computer, an electronic wired or wireless communications device such as a telephone, a cellular telephone, a personal digital assistant, a voice over Internet protocol (VOIP) phone or a smartphone, an interactive television (e.g., a television adapted to be connected to the Internet or an electronic device adapted for use with a television), an electronic pager or any other computing and/or communication device.

[0034] Computers may be linked to one another via a network or networks and/or via wired or wired communications link(s). A "network" may be any plurality of completely or partially interconnected computers wherein some or all of the computers are able to communicate with one another. The connections between computers may be wired in some cases (i.e. via wired TCP connection or other wired connection) or may be wireless (i.e. via WiFi network connection). Any connection through which at least two computers may exchange data can be the basis of a network. Furthermore, separate networks may be interconnected such that one or more computers within one network may communicate with one or more computers in another network. In such a case, the plurality of separate networks may optionally be considered to be a single network.

Terms and Concepts

[0035] The following terms and concepts may be used to better understand the features and functions of systems and methods according to the present disclosure:

[0036] ***Account*** refers to a topmost level within a customer portfolio in the margin account hierarchy (discussed below) where a final margin is reported; the Account is made up of Sectors (discussed below).

[0037] ***Backfilling*** See *Synthetic Price Service* (defined below).

[0038] ***Backtesting*** refers to a normal statistical framework that consists of verifying that actual losses are in line with projected losses. This involves systematically comparing the history of VaR (defined below) forecasts with their associated portfolio returns. Three exemplary backtests may be used to measure the performance of margining according to the present disclosure: *Basel Traffic Light, Kupiec* , and *Christofferson Tests*.

[0039] ***Basel Traffic Light Test*** refers to a form of backtesting which tests if the margin model has too many margin breaches.

[0040] ***Bootstrapping*** See *Correlation Matrix Joint Distribution* (defined below).

[0041] ***Christoffersen Test*** refers to a form of backtesting which tests if the margin model has too many or too few margin breaches and whether the margin breaches were realized on consecutive days.

[0042] ***Cleaned Data*** See *Synthetic Data* (defined below).

[0043] ***Cleaned Historical Dynamic Data (CHDD)*** refers to a process to clean the raw time series data and store the processed financial time series data to be fed into a margin model as input.

[0044] ***Conditional Coverage*** relates to backtesting and takes into account the time in which an exceptions occur. The Christoffersen test is an example of conditional coverage.

[0045] ***Confidence Interval*** defines the percentage of time that an entity (e.g., exchange firm) should not lose more than the VaR amount.

[0046] ***Contingency Group (CG)*** refers to collections of products that have direct pricing implications on one another; for instance, an option on a future and the corresponding future. An example of a CG is Brent = {B, BUL, BRZ, BRM, …}, i.e., everything that ultimately refers to Brent crude as an underlying for derivative contracts.

[0047] ***Contract*** refers to any financial instrument (i.e., any financial product) which trades on a financial exchange and/or is cleared at a clearinghouse. A contract may have a PCC (physical commodity code), a strip date (which is closely related to expiry date), a pricing type (Futures, Daily, Avg., etc.), and so on.

[0048] ***Correlation Matrix Joint Distribution*** refers to a Synthetic Price Service (defined below) approach which builds a correlation matrix using available time series on existing contracts which have sufficient historical data (e.g., 1,500 days). Once a user-defined correlation value is set between a target series (i.e., the product which needs to be backfilled) and one of an existing series with sufficient historical data, synthetic returns for the target can be generated based on the correlation.

[0049] ***Coverage Ratio*** refers to a ratio comparing Risk Charge (defined below) to a portfolio value. This ration may be equal to the margin generated for the current risk charge day divided by the latest available portfolio value.

[0050] ***DB Steering*** refers to an ability to manually or systematically set values in a pricing model without creating an offset between two positions. This may be applicable to certain instruments that are not correlated or fully correlated both statistically and logically (e.g., Sugar and Power).

[0051] ***Diversification Benefit (DB)*** refers to a theoretical reduction in risk a financial portfolio achieved by increasing the breadth of exposures to market risks over the risk to a single exposure.

[0052] ***Diversification Benefit (DB) Coefficient*** refers to a number between 0 and 1 that indicates the amount of diversification benefit allowed for the customer to receive. Conceptually, a diversification benefit coefficient of zero may correspond to the sum of the margins for the sub-portfolios, while a diversification benefit coefficient of 1 may correspond to the margin calculated on the full portfolio.

[0053] ***Diversification Benefit (DB) Haircut*** refers to the amount of the diversification benefit charged to a customer or user, representing a reduction in diversification benefit.

[0054] ***Dynamic VaR*** refers to the VaR of a portfolio assuming that the portfolio's exposure is constant through time.

[0055] ***Empirical Characteristic Function Distribution Fitting (ECF)*** refers to a backfilling approach which fits a distribution to a series of returns and calculates certain parameters (e.g., stability α, scale σ, skewness β, and location μ) in order to generate synthetic returns for any gaps such that they fall within the same calculated distribution.

[0056] ***Enhanced Historical Simulation Portfolio Margining (EHSPM)*** refers to a VaR risk model which scales historical returns to reflect current market volatility using EWMA (defined below) for the volatility forecast. Risk Charges are aggregated according to Diversification Benefits.

[0057] ***Estimated Weighted Moving Average (EWMA)*** is used to place emphasis on more recent events versus past events while remembering passed events with decreasing weight.

[0058] ***Exceedance*** may be referred to as margin breach in backtesting and may be identified when Variation Margin is greater than a previous day's Initial Margin.

[0059] ***Exponentially Weighted Moving Average (EWMA)*** refers to a model used to take a weighted average estimation of returns.

[0060] ***Filtered Data*** refers to option implied volatility surfaces truncated at (e.g., seven) delta points.

[0061] ***Fixed Expiry*** refers to a fixed contract expiration date. As time progresses, the contract will move closer to its expiry date (i.e., time to maturity is decaying). For each historical day, settlement data which share the same contract expiration date may be obtained to form a time series, and then historical simulation may be performed on that series.

[0062] ***Ghost Product*** refers to a synthetic Product created by the PRS system for use in margin calculations. Ghost Products are not true Products: One cannot trade or clear them. They live and die within a margin calculation environment.

[0063] ***Guest Product*** refers to any real products that are cleared by a third party clearinghouse. Guest Products may be used in pricing of contracts.

[0064] ***Haircut*** refers to a reduction in the diversification benefit, represented as a charge to a customer.

[0065] ***Haircut Contribution*** refers to a contribution to the diversification haircut for each pair at each level.

[0066] ***Haircut Weight*** refers to the percentage of the margin offset contribution that will be haircut at each level.

[0067] ***Historical VaR*** uses historical data of actual price movements to determine the actual portfolio distribution.

[0068] ***Holding Period*** refers to a discretionary value representing the time horizon analyzed, or length of time determined to be required to hold assets in a portfolio.

[0069] ***Implied Volatility Dynamics*** refers to a process to compute the scaled implied volatilities using the Sticky-Delta or Sticky-Strike method (defined below). It may model the implied volatility curve as seven points on the curve.

[0070] ***Incremental VaR*** refers to the change in Risk of a portfolio given a small trade. This may be calculated by using the marginal VaR times the change in position.

[0071] ***Independence*** In backtesting, Independence takes into account when an exceedance or breach occurs.

[0072] ***Initial Margin (IM)*** refers to an amount of collateral that a holder of a particular financial product (or financial portfolio) must deposit to cover for default risk.

[0073] ***Input Data*** refers to Raw data that is filtered into cleaned financial time series. The cleaned time series may be input into a historical simulation. New products or products without a sufficient length of time series data have proxy time series created.

[0074] ***Kupiec Test*** refers to a process for testing, in the context of backtesting, which tests if a margin model has too many or too few margin breaches.

[0075] ***Instrument Correlation*** refers to a gain in one instrument that offsets a loss in another instrument on a given day. At a portfolio level, for X days of history (e.g.,), a daily profit and loss may be calculated and then ranked.

[0076] ***Margin Attribution Report*** defines how much of a customer's initial margin charge was from active trading versus changes in the market. In a portfolio VaR model, one implication is that customers' initial margin calculation will not be a sub-process of the VaR calculation. By

using a simple attribution model, the ratio comparing Risk Charge to Portfolio Value (Position Changes and Market Changes) can be displayed.

[0077] ***Margin Offset Contribution*** refers to the diversification benefit of a financial products to a portfolio (e.g., the offset contribution of combining certain financial products into the same portfolio versus margining the financial products separately).

[0078] ***Margin Testing*** - Risk Charge testing may be done to assess how a risk model performs on a given portfolio or financial product. The performance tests may be run on-demand and/or as a separate process, distinct from the production initial margin process. Backtesting may be done on a daily, weekly, or monthly interval (or over any period). Statistical and regulatory tests may be performed on each model backtest. Margin Tests include (without limit) the Basel Traffic light, Kupiec, and Christofferson test.

[0079] ***Marginal VaR*** refers to the proportion of the total risk to each Risk Factor. This provides information about the relative risk contribution from different factors to the systematic risk. The sum of the marginal VaRs is equal to the systematic VaR.

[0080] ***Maturity ID*** refers to a numeric identifier assigned to each contract in Clearing by the Pricing Relationship System (PRS)

[0081] ***Offset*** refers to a decrease in margin due to portfolio diversification benefits.

[0082] ***Offset Ratio*** refers to a ratio of total portfolio diversification benefit to the sum of pairwise diversification benefits. This ratio forces the total haircut to be no greater than the sum of offsets at each level so that the customer is never charged more than the offset.

[0083] ***Option Pricing*** refers to options that are repriced using the scaled underlying and implied volatility data.

[0084] ***Option Pricing Library*** **-** Since underlying prices and option implied volatilities are scaled separately in the MAPS option risk charge calculation process, an option pricing library may be utilized to calculate the option prices from scaled underlying prices and implied volatilities. The sticky Delta technique may also utilize conversions between option strike and delta, which may be achieved within the option pricing library.

[0085] ***Overnight Index Swap (OIS)*** refers to an interest rate swap involving an overnight rate being exchanged for a fixed interest rate. An overnight index swap uses an overnight rate index, such as the Federal Funds Rate, for example, as the underlying for its floating leg, while the fixed leg would be set at an assumed rate. Published OIS rates may be used as inputs for the Yield Curve Generator (YCG) to produce full yield curves for option pricing.

[0086] ***Portfolio Bucketing*** refers to a grouping of clearing member's portfolios (or dividing clearing member's account) in a certain way such that the risk exposure of the clearinghouse can be evaluated at a finer grain. Portfolios are represented as a hierarchy from the clearing member to the instrument level. Portfolio bucketing may be configurable to handle multiple hierarchies.

[0087] ***Portfolio Compression*** refers to a process of mapping a portfolio to an economically identical portfolio with a minimal set of positions. The process of portfolio compression only includes simple arithmetic to simplify the set of positions in a portfolio.

[0088] ***Portfolio Risk Aggregation*** refers to the aggregated risk charge for each portfolio level from bottom-up.

[0089] ***Portfolio Risk Attribution*** refers to the risk attribution for each portfolio from top-down.

[0090] ***Portfolio VaR*** refers to a confidence on a portfolio, where VaR is a risk measure for portfolios. As an example, VaR at a ninety-nine percent (99%) level may be used as the basis for margins.

[0091] ***Position*** In the Margin Account Hierarchy (discussed below), the position level is made up of distinct positions in the cleared contracts within a customer's account. Non-limiting examples of positions may include 100 lots in Brent Futures, -50 lots in Options on WTI futures, and -2,500 lots in AECO Basis Swaps.

[0092] ***Product*** as indicated above, a product (or financial product) may refer to any financial instrument. In fact, the terms product and instrument may be used interchangeably herein. In the context of a Margin Account Hierarchy, Products may refer to groups of physical or financial claims on a same (physical or financial) underlying. Non-limiting examples of Products in this context may include Brent Futures, Options on WTI futures, AECO Natural Gas Basis swaps, etc.

[0093] ***Raw Data*** refers to data which is obtained purely from trading activity recorded via a settlement process.

[0094] ***Raw Historical Dynamic Data (RHDD)*** refers to an ability to store historical financial time series for each unique identifier in the static data tables for each historical day (e.g., expiration date, underlying, price, implied volatility, moneyness, option Greeks, etc.).

[0095] ***Relative Expiry*** - As time progresses, a contract remains at the same distance to its expiry date and every point in the time series corresponds to different expiration dates. For each historical day, settlement data which share the same time to maturity may be used to form the time series.

[0096] ***Reporting*** refers to the reporting of margin and performance analytics at each portfolio hierarchy. A non-limiting example of a portfolio hierarchy grouping includes: Clearing Member, Clearing Member Client, Product type, Commodity type, instrument. Backtest reporting may be performed on regular intervals and/or on-demand.

[0097] ***Return Scaling*** refers to a process to compute and scale returns for each underlying instrument and implied volatility in the CHDD. Scaling may be done once settlement prices are in a clearing system.

[0098] ***Risk Aggregation*** refers to a process to aggregate risk charges from a sub-portfolio level to a portfolio level. This aggregation may be performed using the diversification benefits to off-set.

[0099] ***Risk Attribution*** refers to a process to attribute contributions to the risk charges of portfolios to sub-portfolios.

[0100] ***Risk Charge*** refers to an Initial Margin applied to on the risk charge date.

[0101] ***Risk Charge Performance Measurement*** refer to the performance metrics that are calculated on each backtest, which can be performed at specified intervals and/or by request.

[0102] ***Risk Dashboard*** refers to a risk aggregation reporting tool (optionally implemented in a computing device and accessible via a Graphical User Interface (GUI)) for risk charges across all portfolio hierarchies. The Risk Dashboard may be configured to provides the ability to drill down into detailed analysis and reports across the portfolio hierarchies.

[0103] ***Risk Factors*** – As indicated above, a Risk Factor may refer to any value, rate, yield, underlying product or any other parameter or object that may affect, negatively or positively, a financial product's profitability. Linear instruments may themselves be a risk factor. For each

option product, the underlying instrument for every option expiry may be a risk factor. Seven (7) points on the implied volatility curve for every option expiry may also be risk factors.

[0104] ***Sector*** refers to a level of the Margin Account Hierarchy containing contingency groups. Non-limiting examples of sectors include North American Power, North American Natural Gas, UK Natural Gas, European Emissions, etc.

[0105] ***Specific VaR*** refers to the Risk that is not captured by mapping a portfolio to risk factors.

[0106] ***Static VaR*** refers to the VaR of a portfolio assuming that the portfolio's positions are constant through time.

[0107] ***Sticky Delta Rule*** refers to a rule formulated under the assumption that implied volatility tends to "stick" to delta. The sticky delta rule may be used by quoting implied volatility with respect to delta. Having input a set of fixed deltas, for example, historical implied volatilities which come from pairing each delta to a unique option and matches each input delta with the option whose delta is closest to this input value may be obtained. This process results in an implied volatility surface.

[0108] ***Synthetic Data*** corresponds to any data which has required Synthetic Price Service to backfill prices or fill in gaps where data is lacking.

[0109] ***Synthetic Price Service***, also referred to as Backfilling, refers to a process to logically simulate historical price data where it did not exist, with the goal of building a historical profit and loss simulation to submit into a VaR (Value at Risk) calculation. Non-limiting exemplary algorithms that may be utilized to generate synthetic prices include (without limitation): Empirical Characteristic Function Distribution Fitting (ECF) and Correlation Matrix Joint Distribution (e.g., Bootstrapping).

[0110] ***Systematic VaR*** refers to the Risk that is captured by mapping a portfolio to risk factors.

[0111] ***Time Series*** corresponds to any data which has required Synthetic Price Service to backfill prices or fill in gaps where data is lacking.

[0112] ***Total VaR*** refers to Systematic VaR plus Specific VaR.

[0113] ***Unconditional Coverage*** **-** In backtesting, these tests statistically examine the frequency of exceptions over some time interval. Basel Traffic Light and Kupiec can both be classified as non-limiting examples of unconditional coverage tests.

[0114] ***VaR (Value at Risk)*** refers to the maximum loss a portfolio is expected to incur over a particular time period with a specified probability.

[0115] ***Variation Margin (VM)*** refers to margin paid on a daily or intraday basis based on adverse price movements in contracts currently held in an account. VM may be computed based on the difference between daily settlement prices and the value of the instrument in a given portfolio.

[0116] ***Volatility Cap*** **or** ***Volatility Ceiling*** refers to an upper limit on how high a current backtesting day's forecasted volatility is allowed to fluctuate with respect to a previous backtesting day. The Volatility Cap may be implemented by using a multiplier which defines this upper limit. A Volatility Cap may be used to prevent a system from posting a very high margin requirement due to a spike in market volatility.

[0117] ***Volatility Forecast*** refers to risk factor return volatility that is forecasted using an EWMA. The EWMA model may weight recent information more than past information which makes the risk factor return volatility more adaptive than a standard volatility estimate.

[0118] ***Yield Curve*** describes interest rates (cost of borrowing) plotted against time to maturity (term of borrowing) and is essential to pricing options.

[0119] ***Yield Curve Generator (YCG)*** refers to an algorithm which produces full Yield Curves by interpolating/extrapolating Overnight Index Swap (OIS) rates.

[0120] Exemplary product categorizations according to the present disclosure is summarized below in Table 1.

Table 1: Product Categorization

Financial Group	**Product Category**	**Margin Calculation Type**	**Pricing Type**
Linear	Outright Products	Outright	DLY
			GHOST_DLY
			FUT
			GHOST_FUT
	Average Products	1st Line	1ST_LINE
		Average	AVE
			GHOST_AVE
		Balance of Month	BMO
		Basket	BSK
			GHOST_BSK
	Spread Products	Outright Spread	DIF_PRODUCT_SPREAD
			DIF_CALENDAR_SPREAD
			NG_BAS
		Index Spread	NG_INDEX

		Balmo Spread	SPR_BMO
		Crack Spread	CRK
Non-Linear	Option Products	Option on Outright	OOF
			OOD
			SER
		Option on 1st Line	APO
		Option on Spread	CSO
		Option on Basket	OOC
			GHOST_OOC

Overview

[0121] As noted above, the systems and methods of this disclosure provide a model for more efficiently and accurately determining initial margin. This new model (among other things) is able to scale linearly with the number of underlyings so that the introduction of new products or asset classes does not require an outsized amount of human interaction and ongoing maintenance. The model also allows control of diversification benefits at multiple levels in order to maintain a conservative bias, and may be explainable without large amounts of complex mathematics.

[0122] The present disclosure takes an empirical approach to the risk of portfolios of financial products. As further discussed below, historical simulation may be utilized (as part of the margin model) to minimize the amount of prescription embedded within the risk charge framework, which allows for a more phenomenological approach to risk pricing that ties the

results back to realized market events. The aim has been to make the framework as simple as possible while retaining the core functionality needed.

[0123] Features of the model include (without limitation): utilizing a VaR as the risk measure; determining initial margin based on historical return; scaling market volatility of historical returns to reflect current market volatility; scaling each product in isolation and without considering the market volatility of all other assets; volatility forecasting based on EWMA; full revaluation across the historical period for every position; sticky delta evolution of an option implied volatility surface; modeling an implied volatility surface using delta points (e.g., seven points) on a curve; dynamic VaR over holding periods; aggregating risk charges according to diversification benefits; calculating diversification benefits (DBs) from historical data (DBs can be prescribed as well); performance analysis on sufficient capital coverage and model accuracy; as well as others that will be apparent based on the following descriptions.

[0124] The systems and methods of this disclosure may apply to any type of financial products and combinations thereof, including (without limitation): futures, forwards, swaps, 'vanilla' options (calls and puts), basic exercise (European and American), options (including options on first line swaps), fixed income products (e.g., swaps (IRS, CDS, Caps, Floors, Swaptions, Forward Starting, etc.)), dividend payments, exotic options (e.g., Asian Options, Barrier Options, Binaries, Lookbacks, etc.), exercise products (e.g., Bermudan, Canary, Shout, Swing, etc.).

[0125] The model of the present disclosure may, in an exemplary embodiment, operate under the following assumptions, although said model may be implemented under additional, alternative or fewer assumptions:

a. future volatility of financial returns may be estimated from the past volatility of financial returns;

b. future (forecasts) may be similar to past performance (e.g., volatility, correlations, credit events, stock splits, dividend payments, etc.);

c. EWMA may be utilized to estimate return volatility;

d. an EWMA decay factor (e.g., of 0.97) may be used to weight historical returns;

e. volatility scaling historical returns data to resemble more recent return volatility may be utilized to forecast future return volatility;

f. the volatility of individual underlying products may be adjusted individually;

g. portfolio exposures may be assumed constant over a holding period;

h. the model assumes accurate data is input;

i. disparity in local settlement time does not adversely impact the accuracy of the volatility forecast;

j. a 99% VaR for a 1,000 day return series can be accurately estimated;

k. option implied volatility surface dynamics are relative to the current underlying instrument's price level; and

l. full position valuation may be performed across historical windows of 1,000 days or more.

[0126] Types of information and data that may be utilized by the model may include (without limitation): financial instrument data (e.g., static data (instrument properties), dynamic data (prices, implied volatilities, etc.)), portfolios (composition, diversification benefits, etc.), risk model configurations (e.g., EWMA decay factor, VaR level, days of historical returns, etc.).

[0127] Components of a risk information system according to the present disclosure may include (without limitation): a financial instrument database (to store instrument properties, historical data, etc.), a data filter (to clean erroneous data, fill gaps in data, convert raw data into a time series, etc.), portfolio bucketing (to group portfolios by clearing member, client accounts, product, commodity, market type, etc.), portfolio compression (to net portfolios to a minimal set of positions, e.g., currency triangles, long and shorts on the same instrument, etc.), financial pricing library (e.g., option pricing, implied volatility dynamics, returns calculations, return scaling, etc.), currency conversion (e.g., converts returns to a common return currency for portfolios that contain positions in instruments with more than one settlement currency), risk library (to compute risk at the instrument level, compute risk at the portfolio levels, apply diversification benefits, etc.), performance analysis library (to perform backtests, compute performance measures, produce summary reports and analytics, etc.).

[0128] Turning now to Fig. 1, an exemplary risk engine architecture 100 is shown. This exemplary architecture 100 includes a risk engine manager library 101 that provides main functionality for the architecture 100 and a communication library 102 that provides data communication functionality. Components such as a risk server 105 and a cluster of one or more servers 106 may provide data and information to the communication library 102. Data and information from the communication library 102 may be provided to a risk engine interface library 103, which provides an ‘entrance’ (e.g., daily risk calculation entrance and backtesting functionality entrance) into the risk engine calculation library 104. The risk engine calculation library 104 may be configured to perform daily risk calculations and backtesting functions, as well as all sub-functions associated therewith (e.g., data cleaning, time series calculations, option calculations, etc.).

[0129] The exemplary architecture 100 also may include a unit test library 107, in communication with the communication library 102, risk engine interface library 103 and risk engine calculation library 104, to provide unit test functions. A utility library 108 may be provided in communication with both the risk engine interface library 103 and the risk engine calculation library 104 to provide in/out (I/O) functions, conversion functions and math functions.

[0130] A financial engineering library 109 may be in communication with the utility library 108 and the risk engine calculation library 104 to provide operations via modules such as an option module, time series module, risk module, simulation module, analysis module, etc.

[0131] A reporting library 110 may be provided to receive data and information from the risk engine calculation library 104 and to communicate with the utility library 108 to provide reporting functions.

[0132] Notably, the various libraries, modules and functions described above in connection with the exemplary architecture 100 of Fig. 1 may comprise software components (e.g. computer-readable instructions) embodied on one or more computing devices (co-located or across various locations, in communication via wired and/or wireless communications links), where said computer-readable instructions are executed by one or more processing devices to achieve and provide their respective functions.

[0133] Turning now to Fig. 2, an exemplary diagram 200 showing the various data elements and functions of an exemplary MAPS system according to the present disclosure is shown. More particularly, the diagram 200 shows the data elements and functions provided in connection with products 201, prices 202, returns 203, market risk adaptation 204, historical simulation 205, portfolios 206, margins 207 and reporting 208, and their respective interactions. These data

components and functions may be provided in connection with (e.g., the components may be embodied on) system elements such as databases, processors, computer-readable instructions, computing devices (e.g., servers) and the like.

[0134] An exemplary computer-implemented method of collateralizing counterparty credit risk in connection with one or more financial products may include receiving as input, by at least one computing device, data defining at least one financial product. The computing device may include one or more co-located computers, computers dispersed across various locations, and/or computers connected (e.g., in communication with one another) via a wired and/or wireless communications link(s). At least one of the computing devices comprises memory and at least one processor executing computer-readable instructions to perform the various steps described herein.

[0135] Upon receiving the financial product data, the exemplary method may include mapping, by computing device(s), the financial product(s) to at least one risk factor, where this mapping step may include identifying at least one risk factor that affects a profitability of the financial product(s).

[0136] Next, the method may include executing, by the computing device(s), a risk factor simulation process involving risk factor(s) previously identified. This risk factor simulation process may include retrieving, from a data source, historical pricing data for the one risk factor(s), determining statistical properties of the historical pricing data, identifying any co-dependencies between prices that exist within the historical pricing data and generating, as output, normalized historical pricing data based on the statistical properties and co-dependencies.

[0137] The risk factor simulation process may also include a filtered historical simulation process, which may itself include a co-variance scaled filtered historical simulation that involves

normalizing the historical pricing data to resemble current market volatility by applying a scaling factor to said historical pricing data. This scaling factor may reflect the statistical properties and co-dependencies of the historical pricing data.

[0138] Following the risk factor simulation process, the exemplary method may include generating, by the computing device(s), product profit and loss values for the financial product(s) based on output from the risk factor simulation process. These profit and loss values may be generated by calculating, via a pricing model embodied in the computing device(s), one or more forecasted prices for the financial product(s) based on the normalized historical pricing data input into the pricing model, and comparing each of the forecasted prices to a current settlement price of the financial product(s) to determine a product profit or loss value associated with each of said forecasted prices.

[0139] Next, the computing device(s) may determine an initial margin for the financial product(s) based on the product profit and loss values, which may include sorting the product profit and loss values, most profitable to least profitable or vice versa and selecting the product profit or loss value among the sorted values according to a predetermined confidence level, where the selected product profit or loss value represents said initial margin.

[0140] In one exemplary embodiment, the historical pricing data may include pricing data for each risk factor over a period of at least one-thousand (1,000) days. In this case, the foregoing method may involve: calculating, via the pricing model, one-thousand forecasted prices, each based on the normalized pricing data pertaining to a respective one of the one-thousand days; determining a product profit or loss value associated with each of the one-thousand forecasted prices by comparing each of the one-thousand forecasted prices to a current settlement price of the at least one financial product; sorting the product profit and loss values

associated with each of the one-thousand forecasted prices from most profitable to least profitable or vice versa; and identifying a tenth least profitable product profit or loss value. This tenth least profitable product profit or loss value may represent the initial margin at a ninety-nine percent confidence level.

[0141] An exemplary computer-implemented method of collateralizing counterparty credit risk in connection with a financial portfolio may include receiving as input, by one or more computing device(s), data defining at least one financial portfolio. The financial portfolio(s) may itself include one or more financial product(s). As with the exemplary method discussed above, the computing device(s) used to implement this exemplary method may include one or more co-located computers, computers dispersed across various locations, and/or computers connected (e.g., in communication with one another) via a wired and/or wireless communications link(s). At least one of the computing devices comprises memory and at least one processor executing computer-readable instructions to perform the various steps described herein.

[0142] Upon receiving the financial portfolio data, the exemplary method may include mapping, by the computing device(s), at least one financial product in the portfolio to at least one risk factor by identifying at least one risk factor that affects a probability of said financial product(s).

[0143] Next, the computing device(s) may execute a risk factor simulation process involving the risk factor(s). This risk factor simulation process may include retrieving, from a data source, historical pricing data for the risk factor(s) and determining statistical properties of the historical pricing data. Then, any co-dependencies between prices that exist within the historical pricing

data may be identified, and a normalized historical pricing data may be generated based on the statistical properties and the co-dependencies.

[0144] The risk factor simulation process may further include a filtered historical simulation process. This filtered historical simulation process may include a co-variance scaled filtered historical simulation that involves normalizing the historical pricing data to resemble current market volatility by applying a scaling factor to the historical data. This scaling factor may reflect the statistical properties and co-dependencies of the historical pricing data.

[0145] Following the risk factor simulation process, the exemplary method may include generating, by the computing device(s), product profit and loss values for the financial product(s) based on output from the risk factor simulation process. Generating these profit and loss values may include calculating, via a pricing model embodied in the computing device(s), one or more forecasted prices for the financial product(s) based on the normalized historical pricing data input into said pricing model; and comparing each of the forecasted prices to a current settlement price of the at financial product(s) to determine a product profit or loss value associated with each of said forecasted prices.

[0146] The profit and loss values of the respective product(s) may then be aggregated to generate profit and loss values for the overall financial portfolio(s). These portfolio profit and loss values may then be used to determine an initial margin for the financial portfolio(s). In one embodiment, the initial margin determination may include sorting the portfolio profit and loss values, most profitable to least profitable or vice versa; and then selecting the portfolio profit or loss value among the sorted values according to a predetermined confidence level. The selected portfolio profit or loss value may represent the initial margin.

[0147] In one exemplary embodiment, the historical pricing data may include pricing data for each risk factor over a period of at least one-thousand (1,000) days and the financial portfolio may include a plurality of financial products. In this case, the foregoing method may involve: calculating, via the pricing model, one-thousand forecasted prices for each of the plurality of financial products, where the forecasted prices are each based on the normalized pricing data pertaining to a respective one of the one-thousand days; determining one-thousand product profit or loss values for each of the plurality of financial products by comparing the forecasted prices associated each of the plurality of financial products to a respective current settlement price; determining one-thousand portfolio profit or loss values by aggregating a respective one of the one-thousand product profit or loss values from each of the plurality of financial products; sorting the portfolio profit and loss values from most profitable to least profitable or vice versa; and identifying a tenth least profitable portfolio profit or loss value. This tenth least profitable product profit or loss value may represent the initial margin at a ninety-nine percent confidence level.

[0148] An exemplary system configured for collateralizing counterparty credit risk in connection with one or more financial products and/or one or more financial portfolios may include one or more computing devices comprising one or more co-located computers, computers dispersed across various locations, and/or computers connected (e.g., in communication with one another) via a wired and/or wireless communications link(s). At least one of the computing devices comprises memory and at least one processor executing computer-readable instructions that cause the exemplary system to perform one or more of various steps described herein. For example, a system according to this disclosure may be configured to receive as input data defining at least one financial product; map the financial product(s) to at

least one risk factor; execute a risk factor simulation process (and/or a filtered historical simulation process) involving the risk factor(s); generate product profit and loss values for the financial product(s) based on output from the risk factor simulation process; and determine an initial margin for the financial product(s) based on the product profit and loss values.

[0149] Another exemplary system according to this disclosure may include at least one computing device executing instructions that cause the system to receive as input data defining at least one financial portfolio that includes at least one financial product; map the financial product(s) to at least one risk factor; execute a risk factor simulation process (and/or a filtered historical simulation process) involving the risk factor(s); generate product profit and loss values for the financial product(s) based on output from the risk factor simulation process; generate portfolio profit and loss values for the financial portfolio based on the product profit and loss values; and determine an initial margin for the financial portfolio(s) based on the portfolio profit and loss values.

[0150] A more detailed description of features and aspects of the present disclosure are provided below.

Volatility Forecasting

[0151] A process for calculating forecasted prices may be referred to as *volatility forecasting*. This process involves creating "N" number of scenarios (generally set to 1,000 or any other desired number) corresponding to each risk factor of a financial product. The scenarios may be based on historical pricing data such that each scenario reflects pricing data of a particular day. For products such as futures contracts, for example, a risk factor for which scenarios may be created may include the volatility of the futures' price; and for options, underlying price volatility and the option's implied volatility may be risk factors. As indicated

above, interest rate may be a further risk factor for which volatility forecasting scenarios may be created.

[0152] The result of this volatility forecasting process is to create N number of scenarios, or N forecasted prices, indicative of what could happen in the future based on historical pricing data, and then calculate the dollar value of a financial product or of a financial portfolio (based on a calculated dollar value for each product in the portfolio) based on the forecasted prices. The calculated dollar values (of a product or of a financial portfolio) can be arranged (e.g., best to worst or vice versa) to select the fifth percentile worst case scenario as the Value-at-Risk (VaR) number. Note here that any percentile can be chosen, including percentiles other than the first through fifth percentiles, for calculating risk. This VaR number may then be used to determine an initial margin (IM) for a product or financial portfolio.

[0153] In one embodiment, the methodology used to perform volatility forecasting as summarized above may be referred to as an “exponentially weighted moving average" or "EMWA" methodology. Inputs into this methodology may include a scaling factor (λ) that may be set by a programmed computer device and/or set by user Analyst, and price series data over “N” historical days (prior to a present day). For certain financial products (e.g., options), the input may also include implied volatility data corresponding to a number of delta points (e.g., seven) for each of the "N" historical days and underlying price data for each of the "N" historical days.

[0154] Outputs of this EMWA methodology may include a new simulated series of risk factors, using equations mentioned below.

[0155] For certain financial products such as futures, for example, the EMWA methodology may include:

1. Determining fix parameter values (N):

$$(1) \quad N = 1000, \lambda = .97$$

2. Gathering instrument price series (F_t):
   $F_t, F_{1000}, F_{999}, \dots F_1, where\ F_{1000}\ is\ a\ current\ day's\ settlement\ price$

3. Calculating Log returns r_i:

$$(2) \quad r_i = \log \frac{F_i}{F_{i-1}}$$

4. Calculating sample mean of returns $\hat{u}$:

$$(3) \quad \hat{u} = \frac{1}{N-1} \sum_{i=1}^{N-1} r_t$$

5. Calculating sample variance of returns $\hat{v}$:

$$(4) \quad \hat{v} = \frac{1}{N-2} \sum_{i=1}^{N-1} (r_i - \hat{u})^2$$

6. Calculating EMWA scaled variance ($\hat{e}_j$), this may be the first step of generating a volatility forecast: A first iteration equation may use $\hat{v}$:

$$(5) \quad \hat{e}_j = (1-\lambda) * \left(r_j - \hat{u}\right) + \lambda * \hat{v}$$

   then, a next iteration may proceed as:

$$(6) \quad \hat{e}_j = (1-\lambda) * \left(r_j - \hat{u}\right) + \lambda * \hat{e}_{j-1},$$
$$where\ \hat{e}_{j-1}\ refers\ to\ value\ from\ previous\ iteration$$

7. Calculating EMWA standardized log returns Z_j:

$$(7) \quad z_j = \frac{(r_j - \hat{u}_j)}{\sqrt{\hat{e}_j}} \quad \text{or} \quad z_j = \frac{r_j}{\sqrt{\hat{e}_j}}$$

8. Calculating Volatility $\hat{\sigma}_j$:

$$(8) \quad \sigma_j = \sqrt{\max(v_j, \hat{e}_j)}$$

[0156] For other financial products, such as options for example, the EMWA methodology may include performing all of the steps discussed above in the context of futures (i.e., steps 1-8) for each underlying future price series and for the implied volatility pricing data corresponding to the delta points.

Implied Volatility Dynamics

[0157] When modeling risk for options, the "sticky delta rule" may be used in order to accurately forecast option implied volatility. The 'delta' in the sticky delta rule may refer to a sensitivity of an option's value to changes in its underlying's price. Thus, a risk model system or method according to this disclosure is able to pull implied volatilities for vanilla options and implied correlations for cal spread options (CSOs), for example, by tracking changes in option implied volatility in terms of delta.

[0158] More particularly, the sticky delta rule may be utilized by quoting implied volatility with respect to delta. Having input a set of fixed deltas, historical implied volatilities which come from pairing each delta to a unique option may be obtained. Each input delta may then be matched with the option whose delta is closest to this input value. The implied volatility for each of these options can then be associated with a fixed delta and for every day in history this process is repeated. Ultimately, this process builds an implied volatility surface using the implied volatility of these option-delta pairs. An exemplary implied volatility to delta surface 300 is shown in Fig. 3.

[0159] Using an implied volatility surface, the implied volatility of any respective option may be estimated. In particular, systems and methods according to this disclosure may perform a transformation from delta space to strike space for vanilla options in order to obtain a given option's implied volatility with respect to strike; for CSOs, strikes may be pulled as well. In

other words, given any strike, the systems and method of this disclosure can obtain its implied volatility.

[0160] The sticky delta rule is formulated under the impression that implied volatility tends to "stick" to delta. Under this assumption, changes in implied volatility may be captured by tracking these "sticky deltas." The present disclosure uses these "sticky deltas" as anchors in implied volatility surfaces which are then transformed to strike space in order to quote a given option implied volatility.

[0161] Given inputs of implied volatilities of the "sticky deltas," implied volatility for any given option may be determined. For CSOs, for example, the delta to strike transformation may not be required, since implied correlation is used to estimate prices.

[0162] A delta surface may be constructed using fixed delta points (e.g., seven fixed delta points) and corresponding implied volatilities. Linear interpolation may be used to find the implied volatility of a delta between any two fixed deltas. In practice, the implied volatility surface may be interpolated after transforming from delta space to strike space. This way, the implied volatility for any strike may be obtained. A cross-section 400 of the exemplary implied volatility surface of Fig. 3 is shown in Fig. 4.

[0163] Fig. 5 shows an exemplary implied volatility data flow 500, which illustrates how the EWMA scaling process 505 may utilize as few as one (or more) implied volatility 503 and one (or more) underlying price 504 to operate. This is the case, at least in part, because (historical) implied volatility returns 501 and underlying price series returns 502 are also inputs into the EWMA scaling process 505. EWMA scaling 505 is able to make these return series comparable in terms of a single input price 504 and a single implied volatility 503, respectively. In effect,

EWMA scaling provides normalized or adapted implied volatilities 506 and underlying prices 507.

[0164] The adapted implied volatilities 506 and underlying prices 507 may then be used by a Sticky Delta transformation process 508 to yield adapted implied volatilities with respect to Strike 509. This may then be fed into an interpolation of surface process 510 to yield implied volatilities 511. The implied volatilities 511 as well as EWMA adapted underlying prices 507 may be utilized by an Option Pricer 512, together with option parameters 513 to yield an EWMA adapted option series 514.

Transformation of Delta to Strike

[0165] In order to find the implied volatility for any given vanilla option or CSO, the systems and methods of the present disclosure may utilize a transformation of delta space to strike space. A graphical representation of an exemplary transformation of delta-to-strike 600 is shown in Fig. 6.

[0166] Given any strike, the present disclosure provides means for identifying the respective implied volatility. This transformation may be carried out using the following formula, the parameters of which are defined in Table 2 below:

$$K = \frac{F}{\exp\left(\sigma\sqrt{t} \cdot N^{-1}(\exp(rt)) - \frac{\sigma^2}{2}t\right)} \tag{9}$$

Table 2: Delta to Strike Conversion Parameters

Parameters	Descriptions
$N^{-1}(\cdot)$	The inverse of the cumulative distribution of the standard normal distribution
F	EWMA adapted price of the underlying future
K	Strike price
σ	Volatility of option returns
t	Time to expiry
r	Risk-free rate

Systems and methods according to this disclosure may utilize implied volatility along with EWMA adapted forward price to estimate the price of a financial product such as an option, for example. Details for calculating the EWMA adapted forward price are discussed further below.

[0167] To capture the risk of options (although this process may apply to other types of financial instruments), for example, systems and methods according to this disclosure may track risk factors associated with the financial product. In this example, the risk factors may include: an option's underlying price and the option's implied volatility. As an initial step, an implied volatility surface in terms of delta may be calculated. With this volatility surface, and using the sticky delta rule, the current level of implied volatility for any respective option may be determined.

[0168] Inputs for using the sticky delta rule may include: historical underlying prices, fixed deltas [if seven deltas are used, for example, they may include: .25, .325, .4, .5, .6, .675, .75], historical implied volatilities for each fixed delta, for CSOs, historical implied correlations for each fixed delta, and for CSOs, historical strike for each fixed delta.

[0169] Notably, when calculating VaR for options, implied volatilities may be used to estimate option price. Implied volatility in the options market seems to move with delta. Using the sticky delta rule to track changes in implied volatility may therefore lead to accurate forecasts of implied volatility for all respective securities.

Volatility Ceiling

[0170] A volatility ceiling, or volatility cap, may be an upper limit on how high a current backtesting day's forecasted volatility is allowed to fluctuate with respect to a previous backtesting day. This volatility ceiling may be implemented by using a multiplier which defines this upper limit. In a real-time system, which is forecasting margins instead of using backtesting days, the terminology "yesterday's forecasted volatility" may be used.

[0171] The idea of a volatility ceiling is to prevent the system from posting a very high margin requirement from the client due to a spike in market volatility. A margin call which requires the client to post a large margin, especially during a market event, can to add to systemic risk (e.g., by ultimately bankrupting the client). Hence, the idea would be to charge a margin which is reasonable and mitigates clearinghouse risk.

[0172] If the volatility forecast for a future time period (e.g., tomorrow) is unreasonably high due to a volatility spike caused by a current day's realized volatility, then it is possible that an unconstrained system would charge a very high margin to a client's portfolio under consideration. Typically, this may occur when a market event has occurred related to the products in the client's portfolio. This can also happen if there are 'bad' data points; typically, post backfilling, if returns generated fluctuate too much then this case can be encountered.

[0173] As noted above, charging a very high margin in case of a market event can add on to the systemic risk problem of generating more counterparty risk by potentially bankrupting a

client that is already stretched on credit. Hence, the present disclosure provides means for capping the volatility and charging a reasonable margin which protects the clearinghouse and does not add to the systemic risk issue.

[0174] Inputs into a system for preventing an unreasonably high margin call may include: a configurable multiplier alpha α (e.g., set to value 2), previous backtesting day's (or for live system yesterday's) forecasted volatility, σ_{i-1} and current day's (e.g., today's) forecasted volatility, σ_i. Output of such a system may be based on following equation:

$$(10) \qquad \sigma_i = \min(\sigma_i, \alpha * \sigma_{i-1}),$$

where σ_i is reassigned to a new volatility forecast, which is the minimum of today's volatility forecast, or alpha times yesterday's forecast.

[0175] An initial step in the process includes defining a configurable parameter, alpha, which may be input directly into the system (e.g., via a graphical user interface (GUI) embodied in a computing device in communication with the system) and/or accepted from a control file. Then, the following steps can be followed for different types of financial products.

[0176] For futures (or similar types of products):

1. For backtesting, a variable which holds previous backtesting day's volatility forecast may be maintained in the system; and for a live system, yesterday's volatility forecast may be obtained in response to a query of a database storing such information, for example.

2. The new volatility may be determined based on the following equation:

$$(11) \qquad \sigma_i = \min(\sigma_i, \alpha * \sigma_{i-1})$$

[0177] For options (or similar types of products):

1. For backtesting, a vector of *x-number* (e.g., seven (7)) volatility values for previous day corresponding to the same number (e.g., seven (7)) on delta points on a volatility surface

may be maintained; and for the live system, yesterday's volatility forecast for each of the seven delta points on the volatility surface may be obtained in response to a query of a database, for example.

2. The new volatility corresponding to each point may be determined based on the following equation:

$$(12) \qquad \sigma_i^p = \min\left(\sigma_i^p, \alpha * \sigma_{i-1}^p\right), \text{ where } p \text{ is delta point index}$$

[0178] Under normal market conditions, a volatility cap of α=2 should have no impact on margins.

Configurable Holding Period

[0179] Two notable parameters of VaR models include the length of time over which market risk is measured and the confidence level. The time horizon analyzed, or the length of time determined to be required to hold the assets in the portfolio, may be referred to as the holding period. This holding period may be a discretionary value.

[0180] The holding period for portfolios in a risk model according to this disclosure may be set to be one (1) day as a default, which means only the risk charge to cover the potential loss for the next day is considered. However, due to various potential regulatory requirements and potential changes in internal risk appetite, this value may be configurable to any desired value within the risk architecture described herein. This allows for additional scenarios to be vetted under varying rule sets. The configurable holding period can enhance the ability of the present disclosure to capture the risk for a longer time horizon. The following items illustrate a high level overview of the functionality involved:

a. the holding period, n-days, may be configured in a parameter sheet;

b. the holding period value may impact returns calculations;

c. n-day returns, historical returns over the holding period [e.g., ln(Price(m) / Price(m-n))] may be computed;

d. analytics may be performed on the n-return series;

e. historical price simulations may be performed over the n-day holding period; and

f. profit and loss determinations may be representative of the profit and loss over the holding period.

[0181] With a configurable holding period, the time horizon of return calculations for both future and implied volatility (e.g., for options) may not simply be a single day. Instead, returns may be calculated according to the holding period specified.

[0182] In a VaR calculation, sample overlapping is also allowed. For example, considering a three-day holding period, both the return from day one to day four and the return from day two to day five may be considered to be valid samples for the VaR calculation.

[0183] In backtesting, daily backtests may also be performed. This means performing backtesting for every historical day that is available for the risk charge calculation. However, since the risk charge calculated for each backtesting day may have a multiple-day holding period, risk charge may be compared to the realized profit/loss over the same time horizon.

[0184] Notably, VaR models assume that a portfolio's composition does not change over the holding period. This assumption argues for the use of short holding periods because the composition of active trading portfolios is apt to change frequently. However, there are cases where a longer holding period is preferred, especially because it may be specified by regulation. Additionally, the holding period can be driven by the market structure (e.g., the time required to unwind a position in an over-the-counter (OTC) swaps market may be longer than the exchange traded futures markets). The holding period should reflect the amount time that is expected to

unwind the risk position. Therefore, the present disclosure provides a model with a configurable holding period. This will allow risk management to change the holding period parameter if needed.

Expiration Model

[0185] Systems and methods of the present disclosure may be configured to process financial products having fixed expiries and/or relative expiries. Under the fixed expiry model, for each historical day, settlement data which share the same contract expiration date may be obtained to form a time series, and then historical simulation may be performed on that series. Since the contract expiration date is fixed, as time progresses the contract will move closer to its expiry date (e.g., time to maturity is decaying). An example of a fixed time series 700 is shown in Fig. 7.

[0186] On the other hand, under the relative expiry model, for each historical day, settlement data which share the same time to maturity may be used to form the time series. Therefore, as time progresses the contract will remain at the same distance to its expiry date and every point in the time series may correspond to different expiration dates.

[0187] Turning now to Fig. 8, a chart 800 shows the differences between relative and fixed expiry data. Any data pulled from the fixed expiry model would fall on a fixed expiry curve. This is a curve connecting the price points of the contract that expires at a specific time (e.g., 6/15/2012) on the forward curve day-over-day. Relative expiry data is represented by the curve that connects points of the contract that expire at a specific time period later (e.g., in one year). This figure shows that relative expiry data represents prices from several contracts.

[0188] Take, for example, futures contract A that issued on January '12 with a one year time to expiry. In the case where the contract is fixed expiry, data is obtained such that the contract

will move closer to its expiration date. This implies that price changes can be tracked for contract A by simply using the obtained data as a historical price series.

[0189] On the other hand, if contract A is a relative expiry contract, data is obtained such that the contract quoted will actually remain at the same distance to its expiration date. This implies that the data consists of quotes of different contracts with the same distance to maturity from the given settlement date.

[0190] Another aspect of the present disclosure is the ability to more effectively eliminate the seasonality impact from market risk of a given contract. This aspect may be illustrated in the context of Fig. 9, which shows an example chart 900 of a fixed expiry dataset. As shown in the chart 900, on every historical date (e.g. 10/15/09, 04/15/10, etc.) a MAPS system according to this disclosure may scale the price of the same contract (JUN '12). Notably, a single contract may be quoted for every historical date and rather than price fluctuations caused by seasonality, these price changes may occur since the contract converges to spot price as expiration approaches. Any significant price movement which deviates from the contract's natural convergence to spot, in the fixed expiry data, may be attributed to unpredictable demand or changes in economic climate.

[0191] In the context of a relative expiry dataset, the volatility in a relative expiry time series may be associated to tenor seasonality rather than the volatility of a single tenor. As such, on every historical date in such a time series, a MAPS system according to this disclosure may be configured to scale the price of the contract which expires in a constant time period away from the historical date.

[0192] Inputs into an expiration model (e.g., fixed or relative) may include, for example, a portfolio profile, historical prices and historical volatilities at various delta points. Under the

fixed expiry model, for example, time series data may be assumed to reference the same contract; this means that for every historical date, the data corresponding to one fixed expiration date may be obtained and will form the time series for later scaling purposes.

[0193] An exemplary risk calculation process for calculating a risk of a product may include performing returns calculations which may be used in an EWMA sub-process, the results of which may be used to perform standardized return calculations and volatility forecast and cap calculations. Next, an EWMA adaptation process may be performed before a VaR calculation is performed. An option pricing process (e.g., for options) may also be performed following EWMA adaptation before the VaR calculation occurs.

Option Pricing Library

[0194] Since underlying prices and option implied volatilities may be scaled separately in an option risk charge calculation process of this disclosure, an option pricing library may be utilized to calculate the option prices from scaled underlying prices and implied volatilities. Furthermore, the sticky delta technique described herein may utilize conversions between option strike and delta, which may also achieved within the option pricing library.

[0195] When calculating risk charges for options, a Value-at-Risk (VaR) analysis may utilize a series of projected options values, which may not be directly available and may therefore be calculated from scaled underlying prices and volatilities. Therefore, the options pricing library may be configured to provide an interface for the risk calculator to price options from the scaled values and other parameters.

[0196] The sticky delta method utilizes a conversion from deltas to strikes given option implied volatilities for each delta after which an interpolation can be performed in strike domain to get the interpolated implied volatility for further calculation.

[0197] Examples of inputs for the option pricing library may include (without limitation): for 'vanilla' options, option type (call/put), underlying price, strike, time to expiry, interest rate, and implied volatility. For options on spreads, inputs may include option type (call/put), strike, first leg's underlying price, second leg's underlying price, first leg's underlying volatility, second leg's underlying volatility, time to expiry, interest rate, and implied correlation. For Asian options, inputs may include option type (call/put), underlying price, strike, time to expiry, interest rate, time to first averaging point, time between averaging points, number of averaging points, and implied volatility. For foreign exchange options, inputs may include option type (call/put), underlying price, strike, time to expiry, interest rate, interest rate of foreign currency, and implied volatility. For delta-to-strike conversion, input may include delta, underlying price, strike, time to expiry, interest rate, and implied volatility.

[0198] Outputs of the option pricing library may include an option price (from option pricer) and/or an option strike (from delta-to-strike conversion).

[0199] Optionally, the option pricing library may be an independent module outside of the risk calculation module (e.g., a standalone library regardless of the risk model change). In the risk calculation module, an example function call may be as follows (function format is for illustrative purposes and could differ depending on implementation):

(13) optionPrice = **Black76Pricer**(optionType, underlyingPrice, strike, timeToExpiry, interestRate, impliedVol, marginChoice) or

(14) optionStrike = **DeltaStrikeConverter**(delta, underlyingPrice, strike, timeToExpiry, interestRate, impliedVol, model),

where Black-Scholes, Black76 (both margined and non-margined), spread option, Garmin-Kohlhagen, Barone-Adesi and Whaley, Bachelier, and Curran models may be implemented.

Both margined and non-margined Black76 models may be implemented for delta-to-strike conversion.

Yield Curve Generator (YCG)

[0200] A yield curve describes interest rates (cost of borrowing) plotted against time to maturity (term of borrowing). Yield curves may be utilized for pricing options because options need to be discounted correctly using the interest rate corresponding to their expiration date. Also, interest rates in different countries have a direct relationship to their foreign exchange ("FX") rates and can be used to price forward contracts.

[0201] Yield curves may be generated daily for the settlement process by a python-based yield curve generator, which uses a data feed of Overnight Index Swap (OIS) rates as inputs. A more generic and robust solution may utilize similar algorithms but may be configured as a standalone module providing yield curves based on client-server architecture to various products.

[0202] For calculation of option value (and in turn margin), a yield curve or interest rate corresponding to the expiry of a particular option on the day of calculation (e.g., for the Black-76 model) may be utilized. Historical interest rates to identify volatility against the strike being priced are also utilized. This may be accomplished by first converting the volatility surface from delta to strike space and then interpolating over it. The conversion from delta space to strike space may utilize interest rates for the Black-76 model.

[0203] Notably, use of an interest rate may be dependent on the pricing model being utilized. Thus, in a production level system which may have various pricing models for different instruments, interest rates may or may not be required depending on the instrument and model used to price that instrument.

[0204] Inputs into a yield curve generator module may include (for example) a pricing day's yield curve which for a single options contract may be the interest rate corresponding to the expiration date of the option contract on the pricing date; and/or historical yield curves per VaR calculation day, which for one options contract means the interest rate corresponding to expiration date as of VaR calculation day which may be used for a conversion from delta to strike.

[0205] Accurate margins due to correct interest rates being used for pricing and accurate conversion from delta to strike yield proper YCG rates.

[0206] In operation, assuming the ability to query the historical interest rate curve (yield curve) and current yield curve with granularity of time to maturity in terms of "days" from an available database is possible, the following steps can proceed:

a. Going from delta space to strike space the following formula may be used to convert delta points (e.g., seven delta points) each day into their corresponding strikes. Although the seven delta points in this example (e.g., 0.25, 0.325, 0.4, 0.5, 0.6, 0.675, and 0.75) may be constant, the strikes corresponding to these deltas may change as underlying shifts each day. For the Black-76 model, an equation to go from delta to strike space may comprise the following:

$$(15) \qquad K = F * e^{-(N^{-1}(e^{rT}*\Delta)*\sigma\sqrt{T}-\frac{\sigma^2}{2}*T)},$$

where K = strike, F = futures price, N^{-1} = cumulative normal inverse, T = time to expiry of option, r = interest rate, corresponding to maturity at T, σ = implied volatility and Δ = delta (change in option price per unit change in futures price).

Notably, the interest rate may be different each day in the VaR period when converting from delta to strike (maturity taken with respect to current day).

b. When attempting to re-price options (scenarios) using scaled data through an option pricing formula after EWMA volatility and underlying price scaling, the historical day's interest rate with maturity taken with respect to the margining day {e.g., Today(risk calculation day) + Holding Period in business days} may be taken. The purpose here is to incorporate for interest rate risk.

c. For the backtesting process, the ability to pull historical yield curves to re-price options on the backtesting day may be utilized.

d. a YCG database may provide a daily yield curve with each yield curve giving interest rates against each maturity date starting from next day with increments of one, up to any number of years (e.g., seventy years).

[0207] Examples of option models that may be used in connection with YCG include (without limitation) Black-76, Margined Black-76, Spread-Li CSO, APO (Black-76) and others. Most of these models (except Margined Black-76) require interest rate.

Portfolio Bucketing

[0208] An aspect of the present disclosure is to calculate an initial margin for each clearing member according to the portfolios each member holds in their accounts. Another way to look at it is to attribute the overall market risk for a clearinghouse to each clearing member. However, this will only provide the clearinghouse's risk exposure at clearing member level. Portfolio bucketing provides means for grouping clearing member's portfolios (or divide clearing member's account) such that the risk exposure of the clearinghouse can be evaluated at a more detailed level.

[0209] There are multiple layers under each clearing member account. The systems and method of this disclosure may be configured to attribute an initial margin for a clearing member

to each bucketing component on each layer. Fig. 10 shows an exemplary clearinghouse account hierarchy 1000. As shown, the account hierarchy includes twelve (12) contract position attributes that may pertain to a contract position within a clearing member account. Notably, more, fewer and/or alternative attributes may be utilized in connection with this disclosure.

[0210] For each contract position within a clearing member account, a unique hierarchy path in the structure of Fig. 10 may be identified in order to aggregate initial margins and evaluate risk exposure at each level. After the clearing account hierarchy 1000 is built, a risk exposure to each component ("portfolio bucket") under the hierarchy 1000 may be calculated, with or without accounting for diversification benefit within the bucket. One purpose of attributing initial margin to different portfolio buckets is to evaluate the potential impact on the clearinghouse in scenarios where abnormal market movement occurs for certain markets and to report initial margin for different levels of buckets.

[0211] As noted above, contract positions may exhibit the attributes included in the hierarchy 1000, which may then be fed into a MAPS system according to this disclosure as inputs. In the exemplary hierarchy, for a particular clearinghouse 1001, the attributes include:

1. Clearing member identifier 1002 (e.g., GS, MS, JPM, etc.);
2. Trading member identifier 1003(e.g., TM1, TM2, etc.);
3. Settlement account identifier 1004 (e.g., H, C, F, etc.);
4. Position account identifier 1005 (e.g., D, H, U, etc.);
5. Omnibus account identifier 1006 (e.g., omni1, omni2, NULL, etc.);
6. Customer account identifier 1007 (e.g., cus1, cus2, NULL, etc.);
7. Asset identifier 1008 (e.g., OIL, GAS, etc.);
8. Contingency group identifier 1009 (e.g., BrentGroup, PHEGroup, etc.);

9. Pricing group identifier 1010 (e.g., FUT, OOF, etc.)l
10. Symbol group identifier 1011 (e.g., B, BUL, H, etc.);
11. Expiration group identifier 1012 (e.g., F13, G14, Z14, etc.); and
12. Position identifier 1013.

[0212] Portfolio bucketing and initial margin aggregation will be illustrated in the context of another exemplary hierarchy 1100 shown in Fig. 11, which may apply to customer for Futures/Options (F) and customer Seg Futures (W) on the settlement account level, when the customer accounts are disclosed. It may also apply to the US Customer (C) case. The contract position attributes for a particular clearinghouse 1101, as well as the exemplary (non-limiting) initial margin (IM) calculations, are described below.

1. Clearing member level 1102:

Bucketing criteria: All the contracts that share the same clearing member identifier may be considered to be within one clearing member bucket.

Initial margin calculation: The initial margin attributed to each clearing member bucket may be equal to the summation of the initial margins attributed to all trading member account buckets under it, as shown in the equation (16) below. There may be no diversification benefit applied across trading member accounts.

$$(16)\ \ \mathrm{IM}(\text{Clearing Member i}) = \sum_{j=0}^{n} \mathrm{IM}(\text{Trading Member Account j}|\text{Clearing Member i})$$

2. Trading member level 1103:

Bucketing criteria: All the contracts that share the same clearing member identifier and trading member identifier may be considered to be within one trading member bucket.

Initial margin calculation: The initial margin attributed to each trading member bucket may be equal to the summation of the initial margins attributed to all settlement account buckets under it, as shown in the equation (17) below. There may be no diversification benefit applied across settlement accounts.

$$(17)\quad \text{IM}(\text{Trading Member i}) = \sum_{j=0}^{n} \text{IM}(\text{Settlement Account j}|\text{Trading Member i})$$

3. Settlement account level 1104:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier and settlement account identifier may be considered to be within one settlement account bucket.

Initial margin calculation: The initial margin attributed to each settlement account bucket may be equal to the summation of the initial margins attributed to all position account buckets under it, as shown in the equation (18) below. There may be no diversification benefit applied across position accounts.

$$(18)\quad \text{IM}(\text{Settlement Account i}) = \sum_{j=0}^{n} \text{IM}(\text{Position Account j}|\text{Settlement Account i})$$

4. Position account level 1105:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier and position account identifier may be considered to be within one position account bucket.

Initial margin calculation: The initial margin attributed to each position account bucket may be equal to the summation of the initial margins attributed to all omnibus account buckets and all customer account buckets (when the customer account buckets do not belong to any

omnibus account bucket) under it, as shown in the equation (19) below. There may be no diversification benefit applied across omnibus/customer accounts.

$$(19) \quad \text{IM}(\text{Position Account i}) = \sum_{j=0}^{n} \text{IM}(\text{Omnibus/Customer Account j}|\text{Position Account i})$$

5. Omnibus account level 1106:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier and omnibus account identifier may be considered to be within one omnibus account bucket.

Initial margin calculation: The initial margin attributed to each omnibus account bucket may be equal to the summation of the initial margins attributed to all customer account buckets under it, as shown in equation (20) below. There may be no diversification benefit applied across customer accounts.

$$(20) \quad \text{IM}(\text{Omnibus Account i}) = \sum_{j=0}^{n} \text{IM}(\text{Customer Account j}|\text{Omnibus Account i})$$

6. Customer account level 1107:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier and customer account identifier may be considered to be within one customer account bucket.

Initial margin calculation: The initial margin attributed to each customer account bucket may be calculated directly from summation of the initial margins attributed to all asset group buckets under it, as well as the initial margin calculated from realized portfolio profit / loss (P/L), using diversification benefit calculation algorithms. The following equation (21) may apply:

$$(21)\quad \mathrm{IM}(\text{Customer Account i}) = f_{DB}\left(\sum_{j=0}^{n} \mathrm{IM}(\text{Asset Group j}|\text{Customer Account i}), \mathrm{IM}(\text{Portfolio i})\right)$$

7. Asset group level 1108:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier and asset group identifier may be considered to be within one asset group bucket.

Initial margin calculation: The initial margin attributed to each asset group bucket may be calculated directly from summation of the initial margins attributed to all contingency group buckets under it, as well as the initial margin calculated from realized portfolio P/L, using diversification benefit calculation algorithms. The following equation (22) may be used:

$$(22)\mathrm{IM}(\text{Asset Group i}) = f_{DB}\left(\sum_{j=0}^{n} \mathrm{IM}(\text{Contingency Group j}|\text{Asset Group i}), \mathrm{IM}(\text{Portfolio i})\right)$$

8. Contingency group level 1109:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier, asset group identifier and contingency group identifier may be considered to be within one contingency group bucket.

Initial margin calculation: The initial margin attributed to each contingency group may be calculated directly from the history of all positions it contains (instead of pricing group buckets which are just one level below contingency group), allowing taking full advantage of diversification benefits, using the following equation (23) :

$$(23)\quad \mathrm{IM}(\text{Contingency Group i}) = f_{DB_full}(\text{Position 1}, \text{Position 2}, \ldots \mid \text{Contingency Group i})$$

9. Pricing group level 1110:

Bucketing criteria: All the contracts that share same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier, asset group identifier, contingency group identifier and pricing group identifier may be considered to be within one pricing group bucket.

Initial margin calculation: The initial margin attributed to each pricing group may be calculated directly from the history of all positions it contains (instead of symbol group buckets which are just one level below pricing group), allowing taking full advantage of diversification benefits, using the following equation (24) :

$$(24)\quad \mathrm{IM}(\text{Pricing Group i}) = f_{DB_full}(\text{Position 1}, \text{Position 2}, \ldots \mid \text{Pricing Group i})$$

10. Symbol group level 1111:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier, asset group identifier, contingency group identifier, pricing group identifier and symbol group identifier may be considered to be within one symbol group bucket.

Initial margin calculation: The initial margin attributed to each symbol group may be calculated directly from the history of all positions it contains (instead of expiration group buckets which are just one level below symbol group), allowing taking full advantage of diversification benefits, using the following equation (25):

$$(25)\quad \mathrm{IM}(\text{Symbol Group i}) = f_{DB_full}(\text{Position 1}, \text{Position 2}, \ldots \mid \text{Symbol Group i})$$

11. Expiration group level 1112:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier, asset group identifier, contingency group identifier, pricing group identifier, symbol group identifier and expiration group identifier may be considered to be within one expiration group bucket.

Initial margin calculation: The initial margin attributed to each expiration group may be calculated from the history of all positions it contains, allowing taking full advantage of diversification benefits, as shown in by following equation (26):

$$\text{IM}(\text{Expiration Group i}) = f_{DB_full}(\text{Position 1}, \text{Position 2}, \ldots | \text{Expiration Group i}) \quad (26)$$

12. Position level 1113:

Bucketing criteria: Each bucket on this level only contains one single contract position.

Initial margin calculation: The initial margin attributed to each position group may be calculated as if it were a single asset portfolio. This step may form the basis of initial margin aggregation for a portfolio.

[0213] An exemplary account hierarchy 1200 of non-disclosed customer accounts is shown in Fig. 12. The hierarchy 1200 may apply to customer for Future/Options (F) and Customer Seg Futures (W) on the settlement account level, when the customer accounts are non-disclosed. The contract position attributes for a particular clearinghouse 1201, as well as the exemplary (non-limiting) initial margin (IM) calculations, are described below.

1. Clearing member level 1202:

Bucketing criteria: All the contracts that share the same clearing member identifier may be considered to be within one clearing member bucket.

Initial margin calculation: The initial margin attributed to each clearing member bucket may be equal to the summation of the initial margins attributed to all trading member account buckets under it, as shown in the following equation (27). There may be no diversification benefit applied across trading member accounts.

$$(27) \qquad \text{IM}(\text{Clearing Member i}) = \sum_{j=0}^{n} \text{IM}(\text{Trading Member Account j}|\text{Clearing Member i})$$

2. Trading member level 1203:

Bucketing criteria: All the contracts that share the same clearing member identifier and trading member identifier may be considered to be within one trading member bucket.

Initial margin calculation: The initial margin attributed to each trading member bucket may be equal to the summation of the initial margins attributed to all settlement account buckets under it, as in the following equation (28). There may be no diversification benefit applied across settlement accounts.

$$(28) \qquad \text{IM}(\text{Trading Member i}) = \sum_{j=0}^{n} \text{IM}(\text{Settlement Account j}|\text{Trading Member i})$$

3. Settlement account level 1204:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier and settlement account identifier may be considered to be within one settlement account bucket.

Initial margin calculation: The initial margin attributed to each settlement account bucket may be equal to the summation of the initial margins attributed to all position account buckets under it, as in the following equation (29). There may be no diversification benefit applied across position accounts.

$$(29) \qquad (30)\mathrm{IM}(\text{Settlement Account i}) = \sum_{j=0}^{n} \mathrm{IM}(\text{Position Account j}|\text{Settlement Account i})$$

4. Position account level 1205:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier and position account identifier may be considered to be within one position account bucket.

Initial margin calculation: The initial margin attributed to each position account bucket may be equal to the summation of the initial margins attributed to all omnibus account buckets and all customer account buckets (when the customer account buckets don't belong to any omnibus account bucket) under it, as in the following equation (30). There may be no diversification benefit applied across omnibus/customer accounts.

$$(30) \qquad \mathrm{IM}(\text{Position Account i}) = \sum_{j=0}^{n} \mathrm{IM}(\text{Omnibus/Customer Account j}|\text{Position Account i})$$

5. Omnibus account level 1206:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier and omnibus account identifier may be considered to be within one omnibus account bucket.

Initial margin calculation: The initial margin attributed to each omnibus account bucket may be equal to the initial margins of the non-disclosed customer account buckets under it, as in the following equation (31) .

$$(31) \qquad \mathrm{IM}(\text{Omnibus Account i}) = \mathrm{IM}(\text{Non} - \text{disclosed Customer Account i})$$

6. Customer account level 1207:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier and customer account identifier may be considered to be within one customer account bucket.

Initial margin calculation: The initial margin attributed to each customer account (non-disclosed) bucket may be equal to the summation of the initial margins attributed to all asset group buckets under it, as in the following equation (32). There may be no diversification benefit applied across omnibus/customer accounts.

$$\text{IM}(\text{Customer Account i}) = \sum_{j=0}^{n} \text{IM}(\text{Asset Group j}|\text{Customer Account i}) \tag{32}$$

7. Asset group level 1208:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier and asset group identifier may be considered to be within one asset group bucket.

Initial margin calculation: The initial margin attributed to each asset group bucket may be equal to the summation of the initial margins attributed to all contingency group buckets under it, as in the following equation (33). There may be no diversification benefit applied across contingency group buckets.

$$\text{IM}(\text{Asset Group i}) = \sum_{j=0}^{n} \text{IM}(\text{Contingency Group j}|\text{Asset Group i}) \tag{33}$$

8. Contingency group level 1209:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus

account identifier, customer account identifier, asset group identifier and contingency group identifier may be considered to be within one contingency group bucket.

Initial margin calculation: The initial margin attributed to each contingency group may be equal to the summation of the initial margins attributed to all pricing group buckets under it, as in the following equation (34). There may be no diversification benefit applied across pricing group buckets.

$$\text{IM}(\text{Contingency Group i}) = \sum_{j=0}^{n} \text{IM}(\text{Pricing Group j}|\text{Contingency Group i}) \quad (34)$$

9. Pricing group level 1210:

Bucketing criteria: All the contracts that share same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier, asset group identifier, contingency group identifier and pricing group identifier may be considered to be within one pricing group bucket.

Initial margin calculation: The initial margin attributed to each pricing group may be equal to the summation of the initial margins attributed to all symbol group buckets under it, as in the following equation (35). There may be no diversification benefit applied across symbol group buckets.

$$\text{IM}(\text{Pricing Group i}) = \sum_{j=0}^{n} \text{IM}(\text{Symbol Group j}|\text{Pricing Group i}) \quad (35)$$

10. Symbol group level 1211:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier, asset group identifier, contingency group

identifier, pricing group identifier and symbol group identifier may be considered to be within one symbol group bucket.

Initial margin calculation: The initial margin attributed to each symbol group may be equal to the summation of the initial margins attributed to all expiration group buckets under it, as in the following equation (36). There may be no diversification benefit applied across expiration group buckets.

$$\text{IM}(\text{Symbol Group i}) = \sum_{j=0}^{n} \text{IM}(\text{Expiration Group j}|\text{Symbol Group i}) \quad (36)$$

11. Expiration group level 1212:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, omnibus account identifier, customer account identifier, asset group identifier, contingency group identifier, pricing group identifier, symbol group identifier and expiration group identifier may be considered to be within one expiration group bucket.

Initial margin calculation: The initial margin attributed to each expiration group may be equal to the summation of the initial margins attributed to all position group buckets under it, as in the following equation (37). There may be no diversification benefit applied across position group buckets.

$$\text{IM}(\text{Expiration Group i}) = \sum_{j=0}^{n} \text{IM}(\text{Position Group j}|\text{Expiration Group i}) \quad (37)$$

12. Position level 1213:

Bucketing criteria: Each bucket on this level may only contain one single contract position.

Initial margin calculation: The initial margin attributed to each position group may be calculated as if it were a single asset portfolio.

[0214] Additional exemplary account hierarchies 1300, 1400 are shown in Figs. 13 and 14, respectively. These hierarchies may apply to house accounts (H) and non-US customers (C) on the settlement account level. The contract position attributes for clearinghouses 1301, 1401 as well as the exemplary (non-limiting) initial margin (IM) calculations, are described below.

1. Clearing member level 1302, 1402:

Bucketing criteria: All the contracts that share the same clearing member identifier may be considered to be within one clearing member bucket.

Initial margin calculation: The initial margin attributed to each clearing member bucket may be equal to the summation of the initial margins attributed to all trading member account buckets under it, as in the following equation (38). There may be no diversification benefit applied across trading member accounts.

$$\text{IM}(\text{Clearing Member i}) = \sum_{j=0}^{n} \text{IM}(\text{Trading Member Account j}|\text{Clearing Member i}) \quad (38)$$

2. Trading member level 1303, 1403:

Bucketing criteria: All the contracts that share the same clearing member identifier and trading member identifier may be considered to be within one trading member bucket.

Initial margin calculation: The initial margin attributed to each trading member bucket may be equal to the summation of the initial margins attributed to all settlement account buckets under it, as in the following equation (39). There may be no diversification benefit applied across settlement accounts.

$$\text{IM}(\text{Trading Member i}) = \sum_{j=0}^{n} \text{IM}(\text{Settlement Account j}|\text{Trading Member i}) \quad (39)$$

3. Settlement account level 1304, 1404:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier and settlement account identifier may be considered to be within one settlement account bucket.

Initial margin calculation: The initial margin attributed to each settlement account bucket may be equal to the summation of the initial margins attributed to all position account buckets under it, as in the following equation (40). There may be no diversification benefit applied across position accounts.

$$\text{IM}(\text{Settlement Account i}) = \sum_{j=0}^{n} \text{IM}(\text{Position Account j}|\text{Settlement Account i}) \tag{40}$$

4. Position account level 1305, 1405:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier and position account identifier may be considered to be within one position account bucket.

Initial margin calculation: The initial margin attributed to each position account bucket may be calculated directly from summation of the initial margins attributed to all asset group buckets under it, as well as the initial margin calculated from realized portfolio P/L, using diversification benefit calculation algorithms. An exemplary equation (41) is below:

$$\text{IM}(\text{Position Account i}) = f_{DB}\left(\sum_{j=0}^{n} \text{IM}(\text{Asset Group j}|\text{Position Account i}), \text{IM}(\text{Portfolio i})\right) \tag{41}$$

5. Customer account level 1307, 1407: n/a.

6. Asset group level 1308, 1408:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier and asset group identifier may be considered to be within one asset group bucket.

Initial margin calculation: The initial margin attributed to each asset group bucket may be calculated directly from summation of the initial margins attributed to all contingency group buckets under it, as well as the initial margin calculated from realized portfolio P/L, using diversification benefit calculation algorithms. An exemplary equation (42) is provided below.

$$(42) \quad \mathrm{IM}(\text{Asset Group i}) = f_{DB}\left(\sum_{j=0}^{n} \mathrm{IM}(\text{Contingency Group j}|\text{Asset Group i}), \mathrm{IM}(\text{Portfolio i})\right)$$

7. Contingency group level 1309, 1409:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, asset group identifier and contingency group identifier may be considered to be within one contingency group bucket.

Initial margin calculation: The initial margin attributed to each contingency group may be calculated directly from the history of all positions it contains (instead of pricing group buckets which are just one level below contingency group), as in the following equation (43), allowing taking full advantage of diversification benefits.

$$(43) \quad \mathrm{IM}(\text{Contingency Group i}) = f_{DB_full}(\text{Position 1}, \text{Position 2}, \ldots|\text{Contingency Group i})$$

8. Pricing group level 1310, 1410:

Bucketing criteria: All the contracts that share same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, asset group

identifier, contingency group identifier and pricing group identifier may be considered to be within one pricing group bucket.

Initial margin calculation: The initial margin attributed to each pricing group may be calculated directly from the history of all positions it contains (instead of symbol group buckets which are just one level below pricing group), as in the following equation (44), allowing taking full advantage of diversification benefits.

$$\text{IM}(\text{Pricing Group i}) = f_{DB_full}(\text{Position 1}, \text{Position 2}, \ldots | \text{Pricing Group i}) \quad (44)$$

9. Symbol group level 1311, 1411:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, asset group identifier, contingency group identifier, pricing group identifier and symbol group identifier may be considered to be within one symbol group bucket.

Initial margin calculation: The initial margin attributed to each symbol group may be calculated directly from the history of all positions it contains (instead of expiration group buckets which are just one level below symbol group), as in the following equation (45), allowing taking full advantage of diversification benefits.

$$\text{IM}(\text{Symbol Group i}) = f_{DB_{full}}(\text{Position 1}, \text{Position 2}, \ldots | \text{Symbol Group i}) \quad (45)$$

10. Expiration group level 1312, 1412:

Bucketing criteria: All the contracts that share the same clearing member identifier, trading member identifier, settlement account identifier, position account identifier, asset group identifier, contingency group identifier, pricing group identifier, symbol group identifier and expiration group identifier may be considered to be within one expiration group bucket.

Initial margin calculation: The initial margin attributed to each expiration group may be calculated from the history of all positions it contains, as in the following equation (46), allowing taking full advantage of diversification benefits.

$$\text{IM}(\text{Expiration Group i}) = f_{DB_full}(\text{Position 1}, \text{Position 2}, \ldots | \text{Expiration Group i}) \quad (46)$$

11. Position level 1313, 1413:

Bucketing criteria: Each bucket on this level may only contains one single contract position.

Initial margin calculation: The initial margin attributed to each position group may be calculated as if it were a single asset portfolio.

Diversification Benefit

A diversification benefit process according to this disclosure may assume the following: 1) a customer's account may be considered a portfolio with a natural hierarchy 1500, as shown in Fig. 15; each level of the hierarchy 1500 may have pairwise diversification benefit coefficients defined at each level, which may by default be set up to have zero haircut, meaning no affect on VaR margin; and a haircut may be applied to the diversification benefit at each level (for any reason deemed necessary or desirable).

[0215] In summary, an exemplary process for determining IM that accounts for diversification benefit may include one or more of the following exemplary steps:

a. compute a separate and combined margin at each level of the hierarchy for a customer account;

b. compute a diversification benefit at each level of the hierarchy;

c. perform a diversification attribution at each level of the hierarchy;

d. inside each level, the diversification benefit may be allocated to each possible pair;

e. the diversification benefit coefficient may then be used to haircut the diversification benefit given to the customer account;

f. the sum of the diversification benefit haircuts at each level may then be added on to the fully diversified margin charge; and

g. the haircuts across each level of the hierarchy may be added to arrive at an initial margin.

[0216] Referring again to Fig. 15, components of the exemplary hierarchy 1500 may include levels such as account 1501, sector 1502, contingency group 1503, product 1504 and position 1505. The account level 1501 is shown as the topmost level, which may be the level at which a final initial margin may be reported. An account 1501 may be made up of sectors1502.

[0217] Sectors 1502 may be made up of contingency groups such as, for example, North American Power, North American Natural Gas, UK Natural Gas, European Emissions, etc.

[0218] The contingency group 1503 level may include collections of products that may have direct pricing implications on one another. For example, an option on a future and the corresponding future. An example of a contingency group (CG) may be a Brent = {B, BUL, BRZ, BRM, …}, i.e., everything that ultimately refers to Brent crude as an underlying for derivative contracts. Contingency groups 1503 may be composed of products.

[0219] The product level 1504 may include groups of products, including physical or financial claims on a same (physical or financial) underlying. Non-limiting examples of products include Brent Futures, Options on WTI futures, AECO Natural Gas Basis swaps, etc.

[0220] The position level 1505 may comprise distinct positions in a cleared contracts within a customer's account. Non-limiting examples of positions may be referred to as 100 lots in Brent Futures, -50 lots in Options on WTI futures, and -2,500 lots in AECO Basis Swaps, etc.

[0221] Concepts associated with diversification benefit and the hierarchy discussed above are provided below. Notably, some of the following terms and concepts have already been discussed above. The following descriptions are intended to supplement (and not limit) any of the descriptions provided above.

Margin may be used interchangeably with initial margin, discussed above. Margin may be the amount of capital required to collateralize potential losses from the liquidation of a customer's portfolio over an assumed holding period and to a particular statistical confidence interval.

$$(47) \qquad M_1 = \text{Margin}(\text{Position 1}),\ M_{1,2} = \text{Margin}(\text{Position 1} + \text{Position 2}),$$

where i and j refer to indices across all sectors so Mi may be the margin for the ith sectors and Mi,j refers the margin of a pairwise combined sectors.

Margin Separate (Msep) refers to the sum of the margins calculated on every position's individual profits and loss array in a portfolio. This refers to a worst possible case in which there is no diversification benefit.

$$(48) \qquad \text{Msep} = \text{M}(\text{Position1}) + \text{M}(\text{Position2}) + \text{M}(\text{Position3}) + \ \ldots$$

Margin Combined (Mcomb) refers to a margin calculated on an entire portfolio's profit and loss array. This is the case in which full diversification benefit is given.

$$(49) \qquad \text{Mcomb} = \text{M}(\text{Position1} + \text{Position2} + \text{Position3}\ldots)$$

This may also be referred to as a fully diversified margin.

Offset may refer to a decrease in margin due to portfolio diversification benefits.

$$(50) \qquad \text{Offset} = (\text{Msep} - \text{Mcomb})$$

Haircut may refer to a reduction in the diversification benefit.

Diversification Benefit (DB) may refer to a theoretical reduction in risk a portfolio achieved by increasing the breadth of exposures to market risks over the risk to a single exposure; based, for example, upon a Markowitz portfolio theory. In the context of this disclosure, a diversification benefit (DB) may be a metric of the risk measure reduction an account receives by viewing risk from a portfolio perspective versus a position perspective.

$$DB = Msep - Mcomb \tag{51}$$

Rearranging this equation provides:

$$Mcomb = Msep - DB \tag{52}$$

In this way, the DB may be defined as a "dollar" value.

Diversification Benefit Coefficient (y) may be a number between zero (0) and one (1) that indicates an amount of diversification benefit allowed for an account. Conceptually, a diversification benefit of zero may correspond to the sum of the margins for sub-portfolios, while a diversification benefit of one may be the margin calculated on the full portfolio.

$$Mnew = Msep - y * DB \tag{53}$$

According to the foregoing equation, Mnew may be equal to Msep or Mcomb by setting *y* equal to zero or one respectively.

Diversification Benefit Haircut (h) may refer to the amount of the diversification benefit charged to an account, representing a reduction in diversification benefit. If the subscripts for y_{ij} refer to the sub-portfolios, the diversification benefit haircut can be expressed as one (1) minus y_{ij}, as in the following equation:

$$h_{1,2} = 1 - y_{1,2} \tag{54}$$

This may be the pairwise margin haircut.

Margin Offset Contribution (OC) may refer to the margin offset contribution of combining multiple instruments into the same portfolio versus margining them separately. The offset contribution for a pair of products may be the diversification benefit for that set of portfolios:

$$(55) \quad \mathrm{OC}_{1,2} = \mathrm{M}_1 + \mathrm{M}_2 - \mathrm{M}_{1,2}$$

$$(56) \quad \mathrm{OC}_{1,3} = \mathrm{M}_1 + \mathrm{M}_3 - \mathrm{M}_{1,3}$$

$$(57) \quad \mathrm{OC}_{2,3} = \mathrm{M}_2 + \mathrm{M}_3 - \mathrm{M}_{2,3}$$

Offset Ratio (OR) may refer to the ratio of total portfolio diversification benefit to the sum of pairwise diversification benefits.

$$(59) \quad \mathrm{DB}_{portfolio} = \mathrm{M}_1 + \mathrm{M}_2 + \mathrm{M}_3 - \mathrm{M}_{1,2,3} = \mathrm{M}_{sep} - \mathrm{M}_{comb}$$

$$(60) \quad \mathrm{OR} = \frac{\mathrm{DB}_{portfolio}}{(\mathrm{OC}_{1,2} + \mathrm{OC}_{1,3} + \mathrm{OC}_{2,3})}$$

This ratio forces the total haircut to be no greater than the sum of offsets at each level.

Haircut Weight (w) may refer to the percentage of a margin offset contribution that will be the haircut at each level.

$$(61) \quad \mathrm{w}_{1,2} = \mathrm{h}_{1,2} * \mathrm{OR}$$

$$(62) \quad \mathrm{w}_{1,3} = \mathrm{h}_{1,3} * \mathrm{OR}$$

$$(63) \quad \mathrm{w}_{2,3} = \mathrm{h}_{2,3} * \mathrm{OR}$$

Haircut Contribution (HC) may refer to the contribution to the diversification haircut for each pair at each level.

$$(64) \quad \mathrm{HC}_{1,2} = \mathrm{w}_{1,2} * \mathrm{OC}_{1,2}$$

$$(65) \quad \mathrm{HC}_{1,3} = \mathrm{w}_{1,3} * \mathrm{OC}_{1,3}$$

$$(66) \quad \mathrm{HC}_{2,3} = \mathrm{w}_{2,3} * \mathrm{OC}_{2,3}$$

Level Haircut may refer to the haircut at each level.

$$(67) \quad \text{Haircut} = \text{HC}_{1,2} * \text{HC}_{1,3} + \text{HC}_{2,3}$$

Maps Margin may refer to an actual margin charge.

$$(68) \qquad \text{Mmaps} = \text{Mcomb} + \text{Haircut}$$

[0222] An exemplary diversification benefit process according to this disclosure may include the following process steps.

1. Computing base margins**,** which result in the Mcomb and Msep margin amounts at each level in the account hierarchy. Elements of computing base margins may include identifying a financial portfolio; identifying diversification benefit coefficients associated with the financial portfolio; computing instrument level margins, position level margins and rolling up the positions to compute fully diversified margins for each product separately (i.e., product level margin computation); computing contingency level margins by combining the products into a contingency group level to compute fully diversified margins for each product group separately; computing sector level margins by combining the contingency groups in order to compute fully diversified margins for each sector separately; and computing an account margin by combining the sectors to compute fully diversified margins for an overall account (e.g., a customer account).

2. computing fully diversified margins across all account levels;

3. computing a margin offset across all account levels; and

4. computing diversification haircuts, by: computing inter-sector diversification haircuts; computing inter-contingency group diversification haircuts; computing inter-product diversification haircuts; computing inter-month diversification haircuts; and computing total MAPS margin diversification haircuts.

[0223] Information from this foregoing process may then be compiled into a "dashboard" (which may be displayed via an interactive GUI). An exemplary margin report summary is provided below in Table 3, and an exemplary margin report detail summary is provided in Table 4 below.

Table 3

MAPS Margin Report				
Hierarchy	MAPS Margin w/ Haircut	Full Hist Sim	Full Offset	MAPS DB Haircut
Portfolio	**($5,326,539)**	**($4,428,300)**	**($4,864,945)**	**($898,239)**
Sector	($5,326,539)	($4,666,500)	($238,200)	($47,640)
Contingency Group	($5,278,899)	($6,872,870)	($2,206,370)	($366,524)
Products	($4,912,375)	($6,876,370)	($3,500)	($700)
Position	($4,911,675)	($9,293,245)	($2,416,875)	($483,375)

Table 4

	Full Diversification Margin, Offset, and Haircut Calculations				
	Margin	Offset	Cumulative Offset	Haircut	Cumulative Haircut
	Portfolio	*E-A*	*{E-D}+{D-C}+{C-B} +{B-A}*	*Fh*	*Eh+Dh+Ch+Bh*
A	$ (4,428,300)	$ (4,864,945)	$ (4,864,945)	$ (898,239)	$ (898,239)
	Sector	*B-A*	*{E-D}+{D-C}+{C-B}*	*Bh*	*Eh+Dh+Ch*
B	$ (4,666,500)	$ (238,200)	$ (4,626,745)	$ (483,375)	$ (414,864)
	Contingency Group	*C-B*	*{E-D}+{D-C}*	*Ch*	*Eh+Dh*
C	$ (6,872,870)	$ (2,206,370)	$ (2,420,375)	$ (700)	$ (414,164)
	Products	*D-C*	*{E-D}*	*Dh*	*Eh*
D	$ (6,876,370)	$ (3,500)	$ (2,416,875)	$ (366,524)	$ (47,640)
	Positions	*E-D*		*Eh*	
E	$ (9,293,245)	$ (2,416,875)		$ (47,640)	

[0224] All exemplary embodiments described or depicted herein are provided merely for the purpose of explanation and are in no way to be construed as limiting. Moreover, the words used herein are words of description and illustration, rather than words of limitation. Further, although reference to particular means, materials, and embodiments are shown, there is no limitation to the particulars disclosed herein.

CLAIMS

1. A computer implemented method of collateralizing counterparty credit risk by modeling both linear and non-linear data sets, the method comprising:

receiving as input, by at least one computing device from at least one first computerized data source, data defining at least one first financial product belonging to a first data class defining non-linear financial products ("a non-linear data set") and at least one second financial product belonging to a second data class defining linear financial products ("a linear data set"), said computing device comprising memory and at least one processor executing computer-readable instructions;

empirically modeling, by the at least one computing device, the linear and non-linear data sets by a same empirical modeling process that comprises:

decomposing the at least one first and second financial products into their respective components;

selectively identifying, for each of the at least one first and second financial products, at least one of the respective components that drives profitability, the identified respective components each representing at least one risk factor;

retrieving, by the at least one computing device from at least one second computerized data source, historical pricing data for the at least one risk factor;

executing, by the at least one computing device, a risk factor simulation process involving the at least one risk factor, said risk factor simulation process comprising a filtered historical simulation process;

generating, by the at least one computing device, product profit and loss values for the at least one first and second financial products based on output from the risk factor simulation process; and

determining, by the at least one computing device, an initial margin for the at least one first and second financial products based on the product profit and loss values.

2. The method of claim 1, wherein said decomposing comprising mapping each of the at least one first and second financial products to the at least one risk factor identified as driving profitability.

3. The method of claim 1, wherein the risk factor simulation process further comprises:

determining, by the at least one computing device, statistical properties of the historical pricing data;

identifying, by the at least one computing device, any co-dependencies between prices that exist within said historical pricing data; and

generating, as said output, normalized historical pricing data based on said statistical properties and said co-dependencies.

4. The method of claim 3, wherein the filtered historical simulation process comprises:

executing a co-variance scaled filtered historical simulation that includes:

normalizing the historical pricing data to resemble current market volatility by applying a scaling factor to said historical pricing data, said scaling factor reflecting the statistical properties and co-dependencies of said historical pricing data.

5. The method of claim 3, wherein generating the product profit and loss values comprises:

calculating, via a pricing model embodied in the at least one computing device, one or more forecasted prices for the at least one first and second financial products based on the normalized historical pricing data input into said pricing model; and

comparing each of said forecasted prices to a current settlement price of each of the at least one first and second financial products to determine a product profit or loss value associated with each of said forecasted prices.

6. The method of claim 5, wherein determining the initial margin comprises:

sorting the product profit and loss values, most profitable to least profitable or vice versa; and

selecting the product profit or loss value among the sorted values according to a predetermined confidence level,

wherein the selected product profit or loss value represents said initial margin.

7. The method of claim 6, wherein the historical pricing data comprises pricing data of the at least one risk factor over a period of at least one-thousand (1,000) days, the method further comprising:

calculating, via said pricing model, one-thousand forecasted prices, each based on the normalized pricing data pertaining to a respective one of the one-thousand days;

determining, by the at least one computing device, a product profit or loss value associated with each of the one-thousand forecasted prices by comparing each of the one-thousand forecasted prices to a current settlement price of each of the at least one first and second financial products;

sorting, by the at least one computing device, the product profit and loss values associated with each of the one-thousand forecasted prices from most profitable to least profitable or vice versa; and

identifying, by the at least one computing device, a tenth least profitable product profit or loss value,

wherein said tenth least profitable product profit or loss value represents the initial margin, and

wherein said tenth least profitable product profit or loss value represents a ninety-nine percent confidence level.

8. A computer implemented method of collateralizing counterparty credit risk by modeling both linear and non-linear data sets, the method comprising:

receiving as input, by at least one computing device from at least one first computerized data source, data defining at least one financial portfolio, the at least one financial portfolio comprising at least one first financial product belonging to a first data class defining non-linear financial products ("a non-linear data set") and at least one second financial product belonging to a second data class defining linear financial products ("a linear data set"), said computing device comprising memory and at least one processor executing computer-readable instructions;

empirically modeling, by the at least one computing device, the linear and non-linear data sets by a same empirical modeling process that comprises:

decomposing the linear and non-linear data sets and identifying, for each of the at least one first and second financial products, at least one respective component that drives profitability, the identified at least one respective component representing at least one risk factor;

retrieving, by the at least one computing device from at least one second computerized data source, historical pricing data for the at least one risk factor;

executing, by the at least one computing device, a risk factor simulation process involving the at least one risk factor, said risk factor simulation process comprising a filtered historical simulation process;

generating, by the at least one computing device, product profit and loss values for the at least one first and second financial products based on output from the risk factor simulation process;

generating, by the at least one computing device, portfolio profit and loss values for the at least one financial portfolio based on the product profit and loss values; and

determining, by the at least one computing device, an initial margin for the at least one financial portfolio based on the portfolio profit and loss values.

9. The method of claim 8, wherein said composing comprises mapping each of the at least one first and second financial products to the at least one risk factor identified as driving profitability.

10. The method of claim 8, wherein the risk factor simulation process further comprises:

determining, by the at least one computing device, statistical properties of the historical pricing data;

identifying, by the at least one computing device, any co-dependencies between prices that exist within said historical pricing data; and

generating, as said output, normalized historical pricing data based on said statistical properties and said co-dependencies.

11. The method of claim 10, wherein the filtered historical simulation process comprises a co-variance scaled filtered historical simulation that includes:

normalizing the historical pricing data to resemble current market volatility by applying a scaling factor to said historical data, said scaling factor reflecting the statistical properties and co-dependencies of said historical pricing data.

12. The method of claim 10, wherein generating product profit and loss values comprises:

calculating, via a pricing model embodied in the at least one computing device, one or more forecasted prices for the at least one first and second financial products based on the normalized historical pricing data input into said pricing model; and

comparing each of said forecasted prices to a current settlement price of the at least one first and second financial products to determine a product profit or loss value associated with each of said forecasted prices.

13. The method of claim 12, wherein the generating portfolio profit and loss values comprises:

aggregating at least one respective product profit or loss value from the at least one first and second financial products in said at least one financial portfolio.

14. The method of claim 13, wherein determining the initial margin comprises:

sorting the portfolio profit and loss values, most profitable to least profitable or vice versa; and

selecting the portfolio profit or loss value among the sorted values according to a predetermined confidence level,

wherein the selected portfolio profit or loss value represents said initial margin.

15. The method of claim 14, wherein the historical pricing data comprises pricing data of the at least one risk factor over a period of at least one-thousand (1,000) days and wherein said at least one financial portfolio comprises a plurality of financial products in said first and second data classes, the method further comprising:

calculating, via said pricing model, one-thousand forecasted prices for each of the plurality of financial products, said forecasted prices each based on the normalized pricing data pertaining to a respective one of the one-thousand days;

determining, by the at least one computing device, one-thousand product profit or loss values for each of the plurality of financial products by comparing the forecasted prices associated each of the plurality of financial products to a respective current settlement price;

determining, by the at least one computing device, one-thousand portfolio profit or loss values by aggregating a respective one of the one-thousand product profit or loss values from each of the plurality of financial products;

sorting, by the at least one computing device, the portfolio profit and loss values from most profitable to least profitable or vice versa; and

identifying, by the at least one computing device, a tenth least profitable portfolio profit or loss value,

wherein said tenth least profitable product profit or loss value represents the initial margin, and

wherein the tenth least portfolio product or loss value represents a ninety-nine percent confidence level.

16. A system for collateralizing counterparty credit risk by modeling both linear and non-linear data sets, the system comprising:

at least one computing device comprising memory and at least one processor executing computer-readable instructions that cause the system to:

receive as input, from at least one first computerized data source, data defining at least one first financial product belonging to a first data class defining non-linear financial products ("a non-linear data set") and at least one second financial product belonging to a second data class defining linear financial products ("a linear data set");

empirically model the linear and non-linear data sets by a same empirical modeling process that, when executed, causes the at least one computing device to:

decompose the at least one first and second financial products into their respective components;

selectively identify, for each of the at least one first and second financial products, at least one of the respective components that drives profitability, the identified respective components each representing at least one risk factor;

retrieve, from at least one second computerized data source, historical pricing data for the at least one risk factor;

execute a risk factor simulation process involving the at least one risk factor, said risk factor simulation process comprising a filtered historical simulation process;

generate product profit and loss values for the at least one first and second financial products based on output from the risk factor simulation process; and

determine an initial margin for the at least one first and second financial products based on the product profit and loss values.

17. The system of claim 16, wherein the at least computing device comprises computer-readable instructions that, when executed, cause the system to map each of the at least one first and second financial products to the at least one risk factor identified as driving profitability.

18. The system of claim 16, wherein the at least computing device is configured to:

execute the risk factor simulation process by executing computer-readable instructions that, when executed, cause the system to:

determine statistical properties of the historical pricing data;

identify any co-dependencies between prices that exist within said historical pricing data; and

generate, as said output, normalized historical pricing data based on said statistical properties and said co-dependencies.

19. The system of claim 18, wherein the filtered historical simulation process comprises a co-variance scaled filtered historical simulation and wherein the at least computing device comprises computer-readable instructions that, when executed, cause the system to:

normalize, as part of said co-variance scaled filtered historical simulation, the historical pricing data to resemble current market volatility by applying a scaling factor to said historical pricing data, said scaling factor reflecting the statistical properties and co-dependencies of said historical pricing data.

20. The system of claim 18, wherein the at least computing device is configured to:

generate the product profit and loss values by executing computer-readable instructions that, when executed, cause the system to:

calculate, via a pricing model embodied in the at least one computing device, one or more forecasted prices for the at least one first and second financial products based on the normalized historical pricing data input into said pricing model; and

compare each of said forecasted prices to a current settlement price of each of the at least one first and second financial products to determine a product profit or loss value associated with each of said forecasted prices.

21. The system of claim 20, wherein the at least one computing device is configured to:

determine the initial margin by executing computer-readable instructions that, when executed, cause the system to:

sort the product profit and loss values, most profitable to least profitable or vice versa; and

select the product profit or loss value among the sorted values according to a predetermined confidence level,

wherein the selected product profit or loss value represents said initial margin.

22. The system of claim 21, wherein the historical pricing data comprises pricing data of the at least one risk factor over a period of at least one-thousand (1,000) days, said at least one computing device executing computer-readable instructions that, when executed, cause the system to:

calculate, via said pricing model, one-thousand forecasted prices, each based on the normalized pricing data pertaining to a respective one of the one-thousand days;

determine a product profit or loss value associated with each of the one-thousand forecasted prices by comparing each of the one-thousand forecasted prices to a current settlement price of each of the at least one first and second financial products;

sort the product profit and loss values associated with each of the one-thousand forecasted prices from most profitable to least profitable or vice versa; and

identify a tenth least profitable product profit or loss value,

wherein said tenth least profitable product profit or loss value represents the initial margin, and

wherein said tenth least profitable product profit or loss value represents a ninety-nine percent confidence level.

23. A system for collateralizing counterparty credit risk by modeling both linear and non-linear data sets, the system comprising:

at least one computing device comprising memory and at least one processor executing computer-readable instructions that cause the system to:

receive as input, from at least one first computerized data source, data defining at least one financial portfolio, the at least one financial portfolio comprising at least one first financial product belonging to a first data class defining non-linear financial products (“a non-linear data set”) and at least one second financial product belonging to a second data class defining linear financial products (“a linear data set”);

empirically model the linear and non-linear data sets by a same empirical modeling process that, when executed, causes the at least one computing device to:

decompose the linear and non-linear data sets and identify, for each of the at least one first and second financial products, at least one respective component that drives profitability, the identified at least one respective component representing at least on risk factor;

retrieve, from at least one second computerized data source, historical pricing data for the at least one factor;

execute a risk factor simulation process involving the at least one risk factor, said risk factor simulation process comprising a filtered historical simulation process;

generate product profit and loss values for the at least one first and second financial products based on output from the risk factor simulation process;

generate portfolio profit and loss values for the at least one financial portfolio based on the product profit and loss values; and

determine an initial margin for the at least one financial portfolio based on the portfolio profit and loss values.

24. The system of claim 23, wherein the at least one computing device is configured to map the at least one first and second financial products to the at least one risk factor identified as driving profitability by executing computer-readable instructions.

25. The system of claim 23, wherein the at least one computing device is configured to:

execute the risk factor simulation process by executing computer-readable instructions that, when executed, cause the system to:

determine statistical properties of the historical pricing data;

identify any co-dependencies between prices that exist within said historical pricing data; and

generate, as said output, normalized historical pricing data based on said statistical properties and said co-dependencies.

26. The system of claim 25, wherein the filtered historical simulation process comprises a co-variance scaled filtered historical simulation process and wherein the at least one computing device is configured to execute the co-variance scaled filtered historical simulation process by executing computer-readable instructions that, when executed, cause the system to:

normalize the historical pricing data to resemble current market volatility by applying a scaling factor to said historical data, said scaling factor reflecting the statistical properties and co-dependencies of said historical pricing data.

27. The system of claim 25, wherein the at least one computing device is configured to:

generate product profit and loss values by executing computer-readable instructions that, when executed, cause the system to:

calculate, via a pricing model embodied in the at least one computing device, one or more forecasted prices for the at least one first and second financial products based on the normalized historical pricing data input into said pricing model; and

compare each of said forecasted prices to a current settlement price of the at least one first and second financial products to determine a product profit or loss value associated with each of said forecasted prices.

28. The system of claim 27, wherein the at least one computing device is configured to generate portfolio profit and loss values by executing computer-readable instructions that, when executed, cause the system to aggregate at least one respective product profit or loss value from the at least one first and second financial products in said at least one financial portfolio.

29. The system of claim 28, wherein the at least one computing device is configured to:

determine the initial margin by executing computer-readable instructions that, when executed, cause the system to:

sort the portfolio profit and loss values, most profitable to least profitable or vice versa; and

select the portfolio profit or loss value among the sorted values according to a predetermined confidence level,

wherein the selected portfolio profit or loss value represents said initial margin.

30. The system of claim 29, wherein the historical pricing data comprises pricing data of the at least one risk factor over a period of at least one-thousand (1,000) days and wherein said at least one financial portfolio comprises a plurality of financial products in said first and second data classes, the at least one computing device executing computer-readable instructions that, when executed, cause the system to:

calculate, via said pricing model, one-thousand forecasted prices for each of the plurality of financial products, said forecasted prices each based on the normalized pricing data pertaining to a respective one of the one-thousand days;

determine one-thousand product profit or loss values for each of the plurality of financial products by comparing the forecasted prices associated each of the plurality of financial products to a respective current settlement price;

determine one-thousand portfolio profit or loss values by aggregating a respective one of the one-thousand product profit or loss values from each of the plurality of financial products;

sort the portfolio profit and loss values from most profitable to least profitable or vice versa; and

identify a tenth least profitable portfolio profit or loss value,

wherein said tenth least profitable product profit or loss value represents the initial margin, and

wherein the tenth least portfolio product or loss value represents a ninety-nine percent confidence level.