Margin Models and Their Usage

Part I - Model Design & Methodology

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Content

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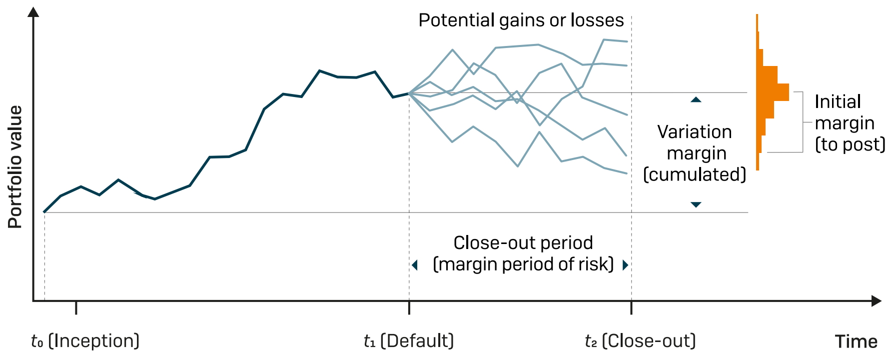
01. Introduction

Margin models are used by central counterparties (CCPs) and other financial institutions to calculate the collateral to be requested from a counterparty in order to mitigate counterparty credit risk.

A common distinction is made between backward-looking and forward-looking margins. Backward-looking margins reflect the current exposure of a portfolio; forward-looking margins quantify its potential future exposure over the liquidation period. The former are usually referred to as Variation Margin (VM) – although other forms exist –, while the latter are known as Initial Margin (IM).

From a modelling perspective, the calculation of Variation Margin requires valuation of the portfolio at the current point in time and essentially depends on the availability of up-to-date market prices and suitable pricing models for all products in the portfolio. Initial Margin models, in contrast, require a statistical framework to model the risk dynamics from the current point in time over the so-called liquidation horizon or margin period of risk (MPOR), i.e., the time needed to close out or hedge the portfolio in the event of a counterparty default.



Historically, margin models were primarily used by CCPs to determine the collateral to be collected from their clearing members in both cash and derivatives markets. Banks also employed (typically relatively simple) margin models for those parts of their business they wished to collateralise, for example with specific clients deemed risky.

The situation changed fundamentally after the global financial crisis of 2007–2008. One major regulatory reform was the introduction of the clearing obligation, which requires most market participants to centrally clear OTC derivatives in specific asset classes. In addition, for the remaining non-centrally cleared derivatives, the obligation to exchange both Variation Margin and Initial Margin was introduced.

This new regulatory landscape has driven substantial further development of Initial Margin models, which have generally become more sophisticated and complex. On the one hand, new regulatory minimum standards had to be met. On the other hand, the need to handle more complex products efficiently created strong incentives to develop state-of-the-art risk methodologies.

Markets

An initial margin model must reflect the specific characteristics of the markets and products to which it is applied.

Financial Markets

These comprise, in particular, equity and fixed-income markets and generally involve the best understood and most liquid products.

Commodity & Energy Markets

These differ from financial markets in key respects, such as the frequent absence of delivery-versus-payment (DvP) mechanisms and the presence of products with inherent modelling challenges (e.g., electricity-related contracts).

Crypto Markets

Crypto-asset markets are relatively new, and some of their products exhibit extremely high volatility and very pronounced price swings.

Today, Initial Margin models are used in several key contexts:

- **Central counterparties (CCPs):** CCPs assume counterparty risk vis-à-vis their clearing members and are responsible for the close-out of a defaulted member's portfolio. To determine the collateral to be collected from members, CCPs operate Initial Margin models whose complexity depends on the cleared asset classes. In recent years, most large CCPs developed and deployed state-of-the-art simulation based models.

- **Clearing service providers (CSPs):** Clearing service providers must monitor and manage the risks generated by their clients, including liquidation of portfolios in case of default. They typically pass on the CCP's margin requirements to their clients, often with an additional scaling factor or further margin components. Some larger CSPs, however, operate their own Initial Margin models.

- **Banks with non-centrally cleared derivatives:** For bilateral, non-centrally cleared derivatives, banks typically use the Standard Initial Margin Model (SIMM) developed by the International Swaps and Derivatives Association (ISDA) [1]. Using a common model reduces disputes between counterparties and streamlines processes.

- **Discretionary Initial Margin at banks:** Banks also use internal Initial Margin models to collect discretionary IM from specific clients, for example hedge funds. These models are often deliberately kept relatively simple.

02. Types of Initial Margin Models

A variety of Initial Margin model types are in use, differing in complexity, risk sensitivity, and operational requirements. The choice of model type is driven by the business context and by trade-offs between development and operating costs on the one side and model sophistication and efficiency on the other. Beyond complexity, other key considerations include market data requirements, netting and diversification capabilities (i.e., the ability to capture offsetting positions and diversification effects), and whether theoretical (re-)valuation of derivatives under specified market data scenarios is required.

The main categories of Initial Margin models in use today are:

- **Notional-based models:** These models use the notionals of positions or trades as the primary input. Notionals are typically multiplied by fixed percentages representing the "volatility" of the respective products. These percentages are external parameters and must be recalibrated regularly. The position-level IM amounts are then summed across the portfolio. Notional-based models are extremely simple – they usually do not require revaluation of positions – but it is difficult to capture diversification and netting effects adequately.

An example is the "grid-based approach" for non-centrally cleared derivatives business [2], which is a simpler alternative to the more complex ISDA SIMM model.

- **Scenario-based models:** In this type of model, a usually small set of hypothetical market movements is applied to the portfolio to calculate potential losses. The magnitudes of these movements ("margin parameters") are calibrated periodically and treated as external inputs. Losses are aggregated across all positions or trades, and the maximum loss across scenarios is taken as the IM figure. Methods exist to reflect netting and diversification effects (such as the "window method"), but they typically operate on a case-by-case basis and are less generic than in fully portfolio-based models. Scenario-based models are still relatively simple and require limited market data for the day-to-day calculation. However, as the risk factor universe becomes more complex – for example in interest rate derivatives –, such models become increasingly cumbersome, since ever more parameters must be specified and maintained.

The most prominent example is the Standard Portfolio Analysis of Risk (SPAN) model, originally developed and maintained by CME [3].

- **Sensitivity-based models:** Sensitivity-based models use position- or trade sensitivities to underlying risk factors, together with risk factor volatilities and correlations, to approximate the portfolio's Value at Risk (VaR). Correlations and volatilities are often treated as external inputs, recalculated only periodically or following significant market changes. These models are genuinely portfolio-based in that offsetting positions and diversification effects are captured in a generic and systematic way.

The most important example is ISDA's Standard Initial Margin Model (SIMM) [1], used for margining of bilateral (non-centrally cleared) derivative portfolios. SIMM is centrally developed, maintained, and recalibrated by ISDA.

- **Simulation-based models:** Simulation-based models generate a large number of hypothetical or historically observed risk factor scenarios, apply them to the current portfolio, and derive a complete profit and loss (P&L) distribution for the portfolio. A risk measure such as Value at Risk (VaR) or Expected Shortfall (ES) is then computed from this distribution to determine the IM figure. Various methods exist to generate risk factor shifts and to model their dependencies, most prominently historical simulations and Monte Carlo simulations.

Simulation-based models are portfolio-based, with netting and diversification effects captured generically. However, they typically require long and high-quality histories of market data and are computationally demanding. They are widely regarded as the most sophisticated type of Initial Margin model currently in use.

Most large CCPs have developed and implemented such models in recent years; examples include Eurex Clearing Prisma [4] and LCH PAIRS [5].

Types of initial margin models used in the market

Type	Notional based models	Scenario matrix based models	Sensitivity based models	Simulation based models
Example	grid-based approach (bilateral margining)	SPAN	SIMM	Eurex Clearing PRISMA
Complexity	very low	low	high	very high
Revaluation required	no	yes	yes	yes
Netting	limited	partial netting possible	covered	covered
Market data requirements	low	low	medium	high / very high

03. Components of Initial Margin Models

At the core of every Initial Margin model lies a market risk model, to which additional elements and add-ons are applied to capture residual risks, such as concentration risks. In principle, the same modelling techniques as in established market risk models in other contexts can be used, for example in banks' internal models. However, Initial Margin models have specific characteristics arising from their particular use case. Important aspects to be considered include:

- **Portfolio view:** Initial Margin models are applied to a high variety of different portfolio constellations. In some settings – such as CCPs – portfolio structures are externally determined by clearing members or clients and can be highly heterogeneous in size and composition. This raises the bar for the choice of a suitable risk factor universe and model architecture and requires robust technical infrastructure. The operational setup must support daily (or even intraday) model runs, monitoring, and analysis, while the validation infrastructure must be able to process and assess a large number of portfolios.

- **Concentration risk:** Almost all contemporary Initial Margin models incorporate mechanisms to penalise large, concentrated positions. This is often a regulatory requirement and reflects the fact that concentrated positions are typically more difficult to liquidate without significant market impact, especially under stressed conditions. Methodological approaches vary considerably, as there is not yet a widely accepted market standard. Key challenges include calibration and choice of calibration data, incorporation of the broader portfolio context, and the design of suitable validation approaches for this model component.

- **Reactivity:** For many applications, it is vital that Initial Margin models respond sufficiently quickly to changing market conditions, for example when a crisis unfolds. Especially in the CCP context, it is a fundamental requirement that IM figures remain risk-appropriate at all times. However, there are notable exceptions – for instance, ISDA SIMM is deliberately designed to be relatively non-reactive.

- **Anti-procyclicality:** In past crises – for example the COVID-19 market turmoil in 2020 or the market stress following the Russian invasion of Ukraine in 2022 –, IM requirements at CCPs and elsewhere often rose sharply, creating sudden liquidity needs for market participants as they sought to provide additional collateral. Regulators have responded by introducing requirements to mitigate procyclical behaviour in IM models (for instance, cf. [6]). These anti-procyclicality considerations can have a strong influence on model design.

CCP Initial Margin Predictability, Transparency, and Anti-Procyclicality

Recent international policy work focuses on improving the predictability and transparency of CCP initial margins and strengthening market participants' liquidity preparedness for large margin calls. The 2022 review of margining practices [7] by the Basel Committee on Banking Supervision (BCBS), the Committee on Payments and Market Infrastructures (CPMI), and the International Organization of Securities Commissions (IOSCO) finds that during the COVID-19 market turmoil of March 2020 margin calls in derivatives and securities markets rose sharply due to extreme market volatility. Overall, post-Global Financial Crisis reforms – including those related to central clearing and margin requirements – helped maintain market resilience, though the report identifies the need for improvements in the transparency and responsiveness of IM models as well as in the liquidity preparedness of market participants.

In response, the 2025 final report on transparency and responsiveness of initial margin in centrally cleared markets by BCBS, CPMI, and IOSCO [8] proposes measures to help regulators and market participants better understand CCP initial margin requirements and their responsiveness. Core elements include more standardised disclosures of IM model structures and key parameters, improved access to margin simulation tools, and common metrics to assess IM responsiveness. The proposals do not prescribe specific modelling choices but aim to reduce unexpected margin calls and enhance the predictability and transparency of CCP initial margins.

The 2024 report on liquidity preparedness for margin and collateral calls [9] by the Financial Stability Board (FSB) complements this by emphasising that greater transparency must be matched by robust liquidity risk management frameworks. Market participants are expected to account for liquidity risks from spikes in margin calls within their governance and risk management frameworks, conduct margin-focused stress tests, and maintain contingency funding plans and effective collateral management practices to ensure liquidity needs can be met even under adverse conditions.

In the European Union, the European Securities and Markets Authority (ESMA) is translating these global developments into the European Market Infrastructure Regulation (EMIR) framework [10]. Under the new EMIR 3.0 regime [11], further work on enhancing margin transparency and responsiveness is already underway or expected in the near future.

Regarding margin transparency, ESMA recently published a final report with draft regulatory technical standards (RTS), setting out requirements for both central counterparties and clearing service providers [12]. On the anti-procyclicality (APC) of CCP initial margin models, ESMA published guidelines and conducted reviews of the existing RTS in recent years, providing further clarification on regulatory expectations for APC measures at CCPs [6] [13].

Further work and dialogue in these areas, involving standard-setting bodies, legislators, central counterparties, market participants, and industry associations, is expected in the coming years.

Value-at-Risk Methodologies

Techniques for modelling Value-at-Risk (VaR) and related quantities such as Expected Shortfall (ES) are well established.

Historically, **parametric VaR models** were among the first to be implemented. These methods use a sensitivity vector Δ and the covariance matrix C as their main inputs. In the most basic form, VaR is given by

$$VaR = q_\alpha \cdot \sqrt{\Delta^t \cdot C \cdot \Delta}$$

These models are relatively robust in terms of market data requirements and computational performance. Although they have largely been superseded by more advanced simulation-based approaches, some prominent Initial Margin models, such as ISDA SIMM, are based on this type of methodology.

Simulation-based approaches generate a large number of shifts r_i^t for all risk factors (i denotes the risk factor, t the time index) and then revalue all positions or trades under each scenario, thereby creating a P&L distribution for the portfolio from which risk measures such as VaR can be derived.

- In **Monte Carlo simulations**, the risk factor shifts are generated from explicitly specified probability distributions using random number generators. The dependence structure between risk factors is captured via the covariance matrix, which is embedded in the distributions, or copulas.

- In **historical simulations**, the risk factor shifts are taken directly from historical time series, so that the empirical dependence structure between risk factors is automatically reflected.

For CCP Initial Margin models, an advanced variant of the historical simulation called filtered **historical simulation** (cf. [14], [15]) has become popular in recent years. In this approach, the historical risk factor shifts r_i^t are rescaled by the ratio of current volatilities σ_i^T and historical volatilities σ_i^t before further processing, which significantly improves the model's responsiveness to changing market conditions, i.e.,

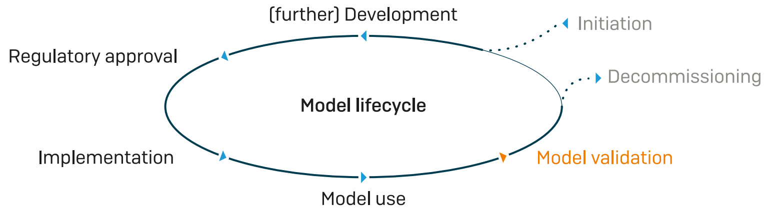
$$r_i^t \rightarrow \sigma_i^T / \sigma_i^t \cdot r_i^t$$

Simulation-based models are the most advanced approaches in the market. They can provide highly risk-sensitive results but place the greatest demands on market data (quality and quantity) and computational resources.

04.

Model Assessment and Model Validation

Model validation aims to ensure the soundness and ongoing adequacy of an implemented and operational model. In many areas, including CCP and bilateral IM models, regulators impose specific minimum requirements. Typically, a full validation must be performed at least annually by sufficiently knowledgeable staff who are independent of the model developers.



As noted earlier, Initial Margin models are essentially market risk models. The established validation toolset used for market risk models in banks and other financial institutions can therefore be applied. Typical qualitative validation activities include:

- **Methodological assessment:** Critical review of the model structure, including model components, risk factor coverage, and suitability for the given product scope.

- **Documentation review:** Verification of correctness, completeness, and consistency of the model documentation.

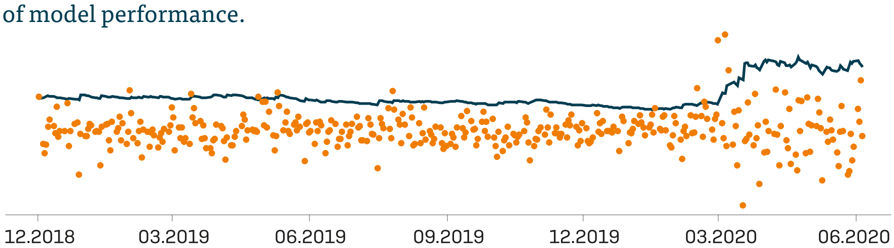
- **Regulatory compliance check:** Assessment of compliance with applicable regulatory frameworks (e.g., for CCP Initial Margin models).

- **Assessment of operational processes:** Review of processes surrounding the model, such as market data sourcing, data quality management, and exception handling.

- **Qualitative benchmarking:** High-level comparison to market standards and to models used by peer institutions.

Quantitative validation activities typically include:

- **Backtesting:** Comparison of historically calculated IM figures with realised portfolio profits and losses (P&Ls). This forms the basis for a statistical assessment of model performance.



- **Quantitative benchmarking:** Comparison of risk figures from the production model with those from a so-called challenger model, typically implemented in a prototypical setup by the validator, to assess the plausibility of levels and dynamics.

- **Parameter sensitivities:** Assessment of how changes in key model inputs, parameters, or assumptions affect IM figures, to evaluate model robustness and the materiality of inputs and assumptions.

Backtesting Market Risk Models

Initial margin models usually provide a Value-at-Risk figure, i.e., an estimate of the loss over a specified time horizon n (the margin period of risk) that will not be exceeded with a given probability α.

For this fixed period of n days, one can compare the IM figures IM_t for a given portfolio to the corresponding clean P&L figures $PnL_{t,t+n}$, i.e., the realised portfolio P&L assuming constant positions over this n-day period. The number r of exceedances, i.e., days where

$$PnL_{t,t+n} < -IM_t\ ,$$

can then be used to evaluate the model statistically. If r is significantly larger than the expected number of exceedances $N \cdot (1\text{-}\alpha)$, where N is the total number of observations considered, the model's adequacy is questionable. Various backtesting tests can be applied to formalise this assessment, most prominently the Basel traffic light approach [16] and the Kupiec test [17].

The specific use case of Initial Margin adds further challenges. The portfolio view requires concepts and technical infrastructure that allow backtesting across large numbers of portfolios and the aggregation of results in a meaningful way. Certain model components, such as liquidity or concentration risk add-ons, may also need to be analysed separately. In addition, dedicated metrics may be required to assess aspects of model behaviour specific to FMIs. In particular, procyclicality should be assessed, for example using measures such as the "peak-to-trough" ratio (see e.g. [18]).

From a validation perspective, IM models are typically assessed along an optimisation triangle of **adequacy**, **cyclicality**, and **efficiency**:

- **Adequacy:** Adequacy refers to the statistical correctness of the model as evidenced by backtesting. For a given confidence level and margin period of risk, the number of backtesting exceedances should be sufficiently low and consistent with the model's calibration. A model that is too aggressive will typically manifest itself in an excessive number of outliers across portfolios, indicating under-margining.

- **Cyclicality:** Cyclicality captures how strongly and how quickly IM reacts to changing market conditions. While IM must be responsive enough to reflect elevated risk, excessively steep increases in margin requirements can create liquidity strains and contribute to procyclical amplification of stress. Metrics such as margin volatility, peak-to-trough ratios, or the frequency and magnitude of step changes in IM can be used to quantify this dimension.

- **Efficiency:** Efficiency relates to capital- and collateral usage. An overly conservative model may produce very few backtesting exceedances and limited cyclicality, but at the cost of structurally high IM levels. This reduces capital efficiency for clearing members and clients and may impair market participation or drive activity to less transparent venues. Efficiency can be assessed, for example, by comparing average IM levels to historical realised losses, by analysing IM relative to portfolio risk measures under alternative models, or by benchmarking against peer CCPs.

These three objectives are inherently in tension. Improving adequacy tends to go along with rising IM levels and/or an increase in cyclicality. Strengthening anti-procyclicality tools, for example by introducing margin floors or buffers, can reduce the speed of IM increases but may worsen efficiency in calm markets. Conversely, attempts to maximise efficiency by lowering IM will typically deteriorate backtesting performance and may necessitate compensating measures in default fund sizing or other safeguards.

A robust validation framework should therefore make these trade offs explicit and transparent, and assess their implications for different stakeholders, including clearing members, clients, and the CCP itself. This includes:

- evaluating adequacy, cyclicality, and efficiency using a consistent set of quantitative metrics;
- documenting how calibration choices (e.g., lookback windows, stress periods, anti-procyclicality tools) position the model within this optimisation triangle; and
- ensuring that governance bodies are aware of the implications of potential recalibrations along each dimension.

The analysis infrastructure for validation must be designed accordingly.

05. Outlook and How d-fine Can Support You

In this white paper, we have discussed the methodology and design principles of Initial Margin models. Technological aspects and practical implementation topics will be addressed in a second part.

Whether you are a bank, a CCP, or another financial market infrastructure operating Initial Margin models or planning to do so, you can benefit from our extensive, decade-long experience with all aspects of such models. d-fine has delivered projects across all stages of the Initial Margin model lifecycle. From development and prototyping through IT architecture design and implementation to business acceptance testing and independent model validation, we have worked with all major types of Initial Margin models across a wide range of markets and institutions.

If you are planning to introduce a new Initial Margin model, require an independent validation of an existing model, or would like to discuss methodological or implementation aspects more generally, please contact us to explore how d fine can support you.

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Authors

Dr Florian Baumann
Partner & Expert in Margin Model Development & Validation
d-fine GmbH, Frankfurt
Florian.Baumann@d-fine.com

Andreas Höcherl
Senior Manager & Expert in Risk Infrastructure & IT Development
d-fine GmbH, Frankfurt
Andreas.Hoecherl@d-fine.com

Dr Alexander Malinowski
Senior Manager & Expert in Margin Model Development & Validation
d-fine GmbH, Frankfurt
Alexander.Malinowski@d-fine.com

Tobias Ringk
Manager & Expert in Margin Model Development & Energy Markets
d-fine GmbH, Frankfurt
Tobias.Ringk@d-fine.com

Tim Blödtner
Senior Consultant & Expert in Margin Model Development
d-fine GmbH, Frankfurt
Tim.Bloedtner@d-fine.com

Berlin
d-fine GmbH
Kurfürstendamm 21
10719 Berlin
Germany
berlin@d-fine.de

Dusseldorf
d-fine GmbH
Gustaf-Gründgens-Platz 5
40211 Dusseldorf
Germany
duesseldorf@d-fine.de

Frankfurt
d-fine GmbH
An der Hauptwache 7
60313 Frankfurt
Germany
frankfurt@d-fine.de

Hamburg
d-fine GmbH
Am Sandtorpark 6
20457 Hamburg
Germany
hamburg@d-fine.de

London
d-fine Ltd
14 Aldermanbury Square
London, EC2V 7HR
United Kingdom
london@d-fine.co.uk

Milan
d-fine s.r.l.
Piazza Sigmund Freud, 1
20124 Milan
Italy
milano@d-fine.com

Munich
d-fine GmbH
Friedenstraße 22b
81671 Munich
Germany
muenchen@d-fine.de

Stockholm
d-fine AB
Kungsgatan 9
11143 Stockholm
Sweden
stockholm@d-fine.se

Stuttgart
d-fine GmbH
Kriegsbergstraße 11
70174 Stuttgart
Germany
stuttgart@d-fine.de

Utrecht
d-fine B.V.
Stadsplateau 7
3521 AZ Utrecht
Netherlands
utrecht@d-fine.nl

Vienna
d-fine Austria GmbH
Seilerstätte 13
1010 Vienna
Austria
wien@d-fine.at

Zurich
d-fine AG
Brandschenkestrasse 150
8002 Zurich
Switzerland
zuerich@d-fine.ch

d-fine