This module should be read in conjunction with the Introduction and with the Glossary, which contains an explanation of abbreviations and other terms used in this Manual. If reading on-line, click on blue underlined headings to activate hyperlinks to the relevant module.

Purpose

To explain the criteria that the MA will use in assessing an AI's eligibility for adopting the internal models approach ("IMM approach") to calculate its market risk for capital adequacy purposes

Classification

A technical note issued by the MA

Previous guidelines superseded

CA-G-3 "Use of Internal Models Approach to Calculate Market Risk" (V.2) dated 31.01.07

Application

To locally incorporated AIs which use, or apply to use, the IMM approach to calculate their market risk for capital adequacy purposes

Structure

1. Introduction

1.1 Terminology

1.1.1 Unless otherwise specified, the terms used in this module have the same meaning as those used in the Banking (Capital) Rules ("the Rules").

1.1.2 For the purposes of this module, the interpretation of certain terms set out in the Rules is recast or elaborated upon as follows[1]:

- "comprehensive risk charge" means the market risk capital charge for specific risk calculated by an AI using the IMM approach to capture not only incremental risks but also all material factors affecting market risk inherent in the AI's correlation trading portfolio;

- "correlation trading portfolio", in relation to an AI, means -

  (a) a portfolio of securitization exposures and/or n^{th}-to-default credit derivative contracts[2] –

    (i) that are neither re-securitization exposures, nor derivatives of securitization exposures that do not provide a pro-rata share in the proceeds of a securitization tranche[3]

[1] The purpose of recasting, or elaborating upon, some of the definitions set out in the Rules is to facilitate AIs' understanding of the defined terms. Notwithstanding this, the definitions set out in the Rules will prevail for the purposes of assessing AIs' compliance with the relevant provisions in the Rules.

[2] See §2(1) and §281 of the Rules for the definition of "securitization exposure" and "n^{th}-to-default credit derivative contract" respectively.

[3] The reference to "derivatives of securitization exposures that do not provide a pro-rata share in the proceeds of a securitization tranche" is intended to capture any complex "double leverage" position, which might not be captured by the definition of "re-securitization exposure" in the Rules.

(this excludes options on a securitization tranche or a synthetically leveraged super-senior tranche);

(ii) where the underlying exposures of the securitization exposures, or the reference entities of the n^{th}-to-default credit derivative contracts are not treated as retail exposures, residential mortgages or commercial mortgages for regulatory capital purposes, regardless of the approach adopted by the AI to calculate capital requirements for credit risk; and

(iii) do not reference any claim on a special purpose entity[4]; and

(iv) where all the reference entities of the n^{th}-to-default credit derivative contracts are single-name products (including single-name credit derivative contracts and commonly traded indices based on single-name products) for which a liquid two-way market exists; and

(b) any positions that hedge the securitization exposures or n^{th}-to-default credit derivative contracts referred to in paragraph (a) of this definition where the positions are neither securitization exposures nor n^{th}-to-default credit derivative contracts, and a liquid two-way market exists for the positions and their underlying exposures;

[4] The intent is to ensure that the special purpose entity ("SPE") structure is not used to evade the criteria that limit the types of positions that may be included in the correlation trading portfolio. Specifically, an AI must exclude from the correlation trading portfolio any instrument issued by a SPE that is backed, directly or indirectly, by a position that would itself be excluded if held by the AI directly. Thus, notes issued by a SPE holding residential or commercial mortgages would not be eligible for inclusion in the correlation trading portfolio, whereas a cash collateralised debt obligation could be included if the underlying assets meet all of the eligibility criteria for a correlation trading portfolio.

- "credit migration risk" means the potential for an AI to incur direct and indirect losses if there were a downgrade or upgrade in an internal or external rating of an exposure or a person (however described);

- "default risk" means the potential for an AI to incur direct and indirect losses if an obligor were to default or a default event were to occur in relation to an exposure of the AI;

- "general market risk" means the risk of loss in the value of an AI's market risk exposures arising from changes in interest rates, exchange rates, equity prices or commodity prices;

- "incremental risk charge" means the market risk capital charge for specific risk calculated by an AI using the IMM approach to capture incremental risks in respect of the AI's trading book positions in -

  (a) specific risk interest rate exposures, other than-

    (i) securitization exposures;

    (ii) n^{th}-to-default credit derivative contracts; and

    (iii) other specific risk interest rate exposures that fall within paragraph (b) of the definition of correlation trading portfolio stated above; and

  (b) listed equities and equity-related derivative contracts based on listed equities;

- "incremental risks" means the default risk and credit migration risk that are not captured (or adequately captured) by an AI's VaR-based calculations;

- "internal capital", in relation to an AI's market risk, means the amount of capital which the AI holds and allocates internally as a result of the AI's assessment of market risk faced by the AI;

- "market risk" means the risk of loss arising from fluctuations in the value of an AI's market risk exposures. It encompasses both specific risk and general market risk;

- "market risk capital charge" means the amount of an AI's capital required to cover general market risk and/or specific risk for its market risk exposures;

- "market risk exposures", in relation to an AI, means -

  (a) the AI's trading book positions held in -

    (i) debt securities;

    (ii) debt-related derivative contracts;

    (iii) interest rate derivative contracts;

    (iv) equities; and

    (v) equity-related derivative contracts; and

  (b) the AI's positions held in -

    (i) foreign exchange (including gold);

    (ii) exchange rate-related derivative contracts;

    (iii) commodities; and

    (iv) commodity-related derivative contracts;

- "market risk management system" means the methods, models, processes, controls and data collection and information technology systems used by an AI which enable the identification, measurement and control of market risk by the AI;

- "risk category", in relation to the calculation of an AI's market risk, means the class of the AI's market risk exposures which are at risk from -

  (a) changes in debt security prices or interest rates;

  (b) changes in exchange rates;

  (c) changes in equity prices; or

  (d) changes in commodity prices;

- "specific risk" means the risk of loss in the value of an AI's market risk exposures arising from -

  (a) changes in the price of debt securities owing to factors relating to the issuers of the debt securities;

  (b) changes in the price of equities owing to factors relating to the issuers of the equities;

  (c) changes in the price of debt-related derivative contracts owing to factors relating to the issuers of the underlying debt securities; and

  (d) changes in the price of equity-related derivative contracts owing to factors relating to the issuers of the underlying equities;

- "specific risk interest rate exposures" means the interest rate exposures of an AI that are subject to a market risk capital charge for specific risk;

- "stressed VaR", in relation to a portfolio of exposures held by an AI, means a VaR calculated

by the AI under the IMM approach with model inputs calibrated to historical data from a stressed VaR relevant period;

- "stressed VaR relevant period", in relation to the calculation of a stressed VaR for a portfolio of exposures held by an AI, means a continuous 12-month period of significant financial stress relevant to that portfolio;

- "two-way market" means a market where there are independent bona fide offers to buy or sell so that a price reasonably related to the last sales price, or current bona fide competitive bid and offer quotations, can be determined within one business day, and transactions can be settled at such price within a relatively short time in accordance with trade custom; and

- "value-at-risk" ("VaR"), in relation to a portfolio of market risk exposures, means a measure of the worst expected loss on the portfolio resulting from market movements over a period of time within a given confidence interval.

1.2 Overview

1.2.1 Part 8 of the Rules sets out the capital adequacy framework for calculating an AI's market risk capital charge[5].

1.2.2 The IMM approach, which is set out in Divisions 11 and 12 of Part 8 of the Rules, is one of the prescribed approaches to the calculation of an AI's market risk. An

[5] Part 8 was amended by the Banking (Capital) (Amendment) Rules 2011, which came into effect on 1 January 2012, to incorporate the enhancements made by the Basel Committee to the market risk capital framework to address weaknesses identified in the 2008/2009 Global Financial Crisis (e.g. inherent limitations of the VaR-based approach, inadequate capture of credit risk and illiquidity associated with trading book exposures, etc.). The enhanced framework comprises two documents, *Revisions to the Basel II market risk framework* (an updated version was issued in February 2011) and *Guidelines for computing capital for incremental risk in the trading book*.

AI may use this approach only if it has the MA's approval to do so under §18(2)(a) of the Rules.

1.2.3 AIs are advised to read this module in conjunction with the Rules. In case of any discrepancy between this module and the Rules, the Rules will prevail.

1.3 Application for use of IMM approach

1.3.1 An AI may submit an application under §18(1) of the Rules, for the MA's approval under §18(2), to use the IMM approach to calculate the market risk capital charge for general market risk or specific risk, or both, for its market risk exposures. The manner in which an AI should submit such an application is described in §18(1A) of the Rules.

1.3.2 As extracted below, Table 1A under §18(9) of the Rules sets out the market risk capital charges that have to be calculated for each of the four risk categories under the IMM approach. The MA's prior approval is required for the calculation of these charges should the IMM approach be used.

Table 1A - Market Risk Capital Charge under IMM Approach

Risk category	General market risk	Specific risk	
Column 1	Column 2	Column 3	Column 4
1. Interest rate exposures	VaR Stressed VaR	VaR Stressed VaR	Incremental risk charge Comprehensive risk charge
2. Equity exposures	VaR Stressed VaR	VaR Stressed VaR	Incremental risk charge
3. Foreign exchange (including gold) exposures	VaR Stressed VaR	—	—
4. Commodity exposures	VaR Stressed VaR	—	—

1.3.3 The MA will make a determination under §18(2) in respect of any application that complies with §18(1A). The MA may grant approval to an AI under §18(2)(a), subject to any conditions the MA thinks proper in any particular case (see §33A of the Rules), to use the IMM approach to calculate all (but not part) of the market risk capital charges that fall within a "group of relevant charges"[6] as defined in §18(9), provided that the AI

[6] A "relevant charge" means the market risk capital charge under the IMM approach specified in Column 2, 3 or 4 of Table 1A. The "group of relevant charges" defined in §18(9) refers to those relevant charges that are applicable to an AI in respect of the use

demonstrates to the satisfaction of the MA that the requirements specified in Schedule 3 to the Rules applicable to or in relation to the AI are met. The relevant criteria are described in sections 2, 3 and 4.

1.3.4 As an illustration, if an AI intends to use the IMM approach to calculate general market risk for foreign exchange (including gold) exposures, it means that the AI has to model both VaR and stressed VaR for such exposures (see paragraph (a) of the definition of "group of relevant charges" in §18(9)). In order to comply with §18(1A)(a), the AI has to submit an application under §18(1) in respect of both VaR and stressed VaR for calculating general market risk for its foreign exchange (including gold) exposures (unless it already has the MA's approval to calculate VaR[7]). The MA may either grant approval for the AI's application, or refuse to grant the approval, under §18(2).

1.3.5 The MA's approval for an AI to use the IMM approach may be granted on a partial basis under §18(5) of the Rules if the MA is satisfied that it is not practicable for the AI, or the AI is not yet ready, to use the IMM approach to calculate both specific risk and general market risk, or to use this approach across all of its risk categories or business.

1.3.6 An AI may also seek the MA's approval under §23A of the Rules to exempt a portfolio of market risk positions that fall within a risk category from the AI's IMM calculations if it can meet the specified requirements set out in §23A(2)(a)(i) to (iii). The circumstances under which the exemption will be revoked are set out in §23B of the Rules.

1.3.7 Where necessary, the MA may request for a period of initial monitoring and live testing of an AI's internal

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of the IMM approach to calculate general market risk for individual risk categories, specific risk for interest rate exposures, and specific risk for equity exposures.

[7] If the AI had already obtained the MA's approval to calculate VaR for general market risk for its foreign exchange (including gold) exposures prior to 1 January 2012, the application concerned will only need to cover stressed VaR for such exposures.

models before the models are allowed to be used by the AI for capital adequacy purposes. Any AI which intends to use internal models to calculate its market risk should be prepared to participate in any such testing exercise to facilitate the MA's assessment of the accuracy and reliability of such models (see also section 5).

1.4 Transitional arrangements for Banking (Capital) (Amendment) Rules 2011

1.4.1 §18A of the Rules sets out the transitional arrangements relating to approvals granted by the MA under §18(2) that were in force immediately before the commencement of the Amendment Rules on 1 January 2012.

1.4.2 AIs that obtained the MA's approval under §18(2)(a) to use the IMM approach to calculate market risk prior to 1 January 2012, and that wish to continue using the IMM approach on and after 1 January 2012, are required to obtain the MA's approval in respect of any new market risk capital charge (as per Table 1A) applicable to them. These AIs were given a six-month grace period for obtaining such approval.

1.4.3 An approval for using the IMM approach to calculate VaR for general market risk or specific risk, or both, existing immediately before 1 January 2012 is deemed to remain in force on and after 1 January 2012 (see §18A(1)), but this "deemed approval" would generally be deemed to be revoked on 1 July 2012 if the requisite approval for any new market risk capital charge applicable to the AI concerned (i.e. stressed VaR and, where applicable, incremental risk charge or comprehensive risk charge) was not obtained before 1 July 2012 (see §18A(4)(a)). §18A(4)(b) covers the situation where an AI's application was still in the process of determination by the MA on 1 July 2012.

1.4.4 If the requisite approval for any new market risk capital charge related to a deemed approval was not obtained upon the commencement of the Amendment Rules on

1 January 2012, the AI concerned was required to use the standardized (market risk) approach ("STM approach")[8] to calculate market risk for the positions covered in that deemed approval on and after 1 January 2012, until such requisite approval was obtained no later than 30 June 2012. If such approval was not obtained within this time, the deemed approval would be deemed to be revoked on 1 July 2012 (unless specified otherwise under §18A(4)(b)). See §18A(3) for details of the requisite approval(s) required under the Rules during the transitional period.

2. Qualitative criteria

2.1 Board and senior management oversight

2.1.1 The Board of Directors (or a committee with delegated authority from the Board) and senior management of an AI are expected to be actively involved in the market risk management process and to regard market risk management as an essential aspect of the business to which significant resources need to be devoted. In particular, they should -

- set the AI's risk appetite or tolerance for market risk, which should be consistent with its overall risk appetite or tolerance;
- approve all key elements of, and any material changes to, the AI's market risk management system;
- possess an understanding of the market risk activities of the AI and the key assumptions and limitations of the AI's internal models, as well as the operation of, and the management reports generated by, the AI's market risk management system, adequate for them to perform their

[8] The STM approach is set out in Divisions 2 to 10 of Part 8 of the Rules.

functions including particularly those specified in this subsection;

- exercise oversight of the AI's market risk management system sufficient to ensure that the system complies with subsection 2.2; and

- ensure that there is a reporting system within the AI to provide sufficient information (including that relating to any material changes to, or deviations from, established policies and procedures or any material findings identified in independent reviews or audits conducted in accordance with subsection 2.9) to them regularly as will enable them to exercise sufficient oversight as required above and make informed decisions relating to the AI's market risk exposures (e.g. in terms of formulating trading strategies or setting trading limits).

2.2 Market risk management system

2.2.1 An AI's market risk management system should be -

- suitable for the purposes of identifying, measuring and controlling the AI's market risk on a firm-wide basis, taking into account the characteristics and extent of the AI's market risk exposures; and

- operated in a prudent and consistently effective manner.

2.2.2 An AI should have policies and procedures to ensure that the valuation of the AI's market risk exposures is prudently made whenever there are uncertainties affecting the accuracy of valuation estimates. In this regard, the provisions in §4A of the Rules are relevant[9].

[9] §4A sets out the enhanced prudent valuation requirements, including the need to make valuation adjustments (which may exceed adjustments made by AIs in accordance with applicable financial reporting standards), for exposures measured at fair value. §48(1)(f) requires that an AI must deduct from its core capital the amount of any valuation adjustment made in respect of an exposure of the AI that gives rise to a reduction in the

2.3 Market risk control unit

2.3.1 An AI should have a market risk control unit which is functionally independent of the AI's staff and management responsible for originating and trading market risk exposures (i.e. trading units) and reports directly to the AI's senior management. This unit should generally be responsible for -

- the design or selection of the AI's market risk management system;
- the testing and implementation of the AI's market risk management system;
- the oversight of the effectiveness of the AI's market risk management system;
- the production and analysis of daily management reports based on the output of the AI's internal models (including an evaluation of the relationship between measures of market risk exposures and trading limits);
- the ongoing review of, and changes to, the AI's market risk management system; and
- the conduct of a regular (at least quarterly) back-testing programme to verify the accuracy and reliability of the AI's internal models. This refers to an ex-post comparison of the VaR measures generated by the internal models against the actual daily changes in portfolio value over time as well as the hypothetical changes in portfolio value based on static positions[10].

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value of the exposure. For additional guidance see CA-S-10 "Financial Instrument Fair Value Practices".

[10] This assumes that end-of-day positions remain unchanged during the holding period (say one day).

2.4 Market risk factors

2.4.1 An AI's internal models should capture and accurately reflect, on a continuing basis, all material factors affecting market risk inherent in the AI's market risk exposures (see Annex A for specification of these market risk factors).

2.4.2 In addition, an AI should include all factors that are deemed relevant for pricing as risk factors in its internal models. Where a risk factor is incorporated in a pricing model but not in the VaR model, the AI must justify this omission to the satisfaction of the MA.

2.4.3 An AI's internal models should also capture non-linearities for option contracts and other relevant products (e.g. mortgage-backed securities, tranched exposures or n^{th}-to-default credit derivative contracts), as well as correlation risk and basis risk (e.g. between credit default swaps and bonds). Moreover, any proxies used should demonstrate a good track record vis-à-vis the actual position held (e.g. an equity index for a position in an individual stock).

2.5 Use of internal models

2.5.1 An AI's internal models should play an essential role in the AI's daily risk management process. The model outputs should accordingly be used in the process of planning, monitoring and controlling the AI's market risk.

2.5.2 The VaR measures generated from an AI's internal models should, in particular, be used for determining the AI's trading limits. The relationship between the AI's internal models and those limits should be maintained consistently over time and understood by the AI's senior management and staff engaged in trading activity.

2.5.3 An AI should have a sufficient number of staff who are qualified and trained to use internal models in the AI's business, risk control, audit and back-office functions as

will enable these functions to work effectively in identifying, measuring and controlling the AI's market risk.

2.6 Compliance and documentation

2.6.1 An AI should clearly document its internal models and the internal policies, controls and procedures relating to the operation of the models and have a system for monitoring and ensuring compliance with those internal policies, controls and procedures.

2.6.2 There should, for example, be a manual that describes the basic principles of an AI's market risk management system and provides an explanation of the empirical techniques used to calculate the AI's market risk.

2.7 Internal validation

2.7.1 An AI's internal models should have a proven track record of acceptable accuracy in calculating market risk (see Annex B for the use and interpretation of back-testing results).

2.7.2 An AI should have a reliable system for validating the accuracy and consistency of the AI's internal models by parties -

- who are qualified and trained to do so (i.e. with relevant and sufficient expertise and experience); and

- who are independent of the trading functions and the development of the internal models,

with the aim of ascertaining whether the internal models are conceptually sound and able to capture all material factors affecting market risk (see subsection 2.4).

2.7.3 Such model validation should be conducted by an AI when an internal model is initially developed or when any significant changes are made to the internal model.

2.7.4 Such model validation should be conducted regularly or when there have been significant structural changes in the market or changes to the composition of the AI's portfolio of exposures which might lead to the internal model concerned no longer being adequate to capture all material factors affecting market risk (see subsection 2.4).

2.7.5 An AI should have appropriate methods and procedures for assessing the validity and performance of, and the results generated by, its internal models. The AI should also have procedures to ensure that both the assumptions and approximations underlying its internal models are prudent and appropriate for the calculation of its market risk.

2.7.6 For the purposes of para. 2.7.5, model validation should not be limited to back-testing. An AI should also use other model validation techniques appropriate for assessing the validity of its internal models, including –

- tests to demonstrate that any assumptions made within the AI's internal models are appropriate and do not under-estimate risk. These assumptions may include the use of normal distribution, the use of square root of time to scale from a one-day holding period to a 10-day holding period and those associated with the use of extrapolation or interpolation techniques or pricing models;

- in addition to those required under the regulatory back-testing framework adopted by the MA (see Annex B for more details), tests using hypothetical changes in portfolio value that would occur were end-of-day positions to remain unchanged. Additional tests should be conducted where appropriate, including –

  (a) testing carried out for periods (e.g. three years) longer than normally required for an AI's regular back-testing programme. The longer time period generally improves the power of back-testing, except when the AI's

internal models or market conditions have changed to the extent that historical data are no longer relevant;

(b) testing carried out using confidence intervals other than the 99% confidence interval required under para. 3.2.2; and

(c) testing of sub-portfolios[11]; and

- the use of hypothetical portfolios to ensure that an AI's internal models are able to account for particular structural features that may arise, for example -

(a) where the data history for a particular instrument does not meet the quantitative criteria set out in section 3 and where the AI needs to map these positions to proxies, it should ensure that the proxies produce prudent results under relevant market scenarios;

(b) the AI should ensure that material basis risks are adequately captured. These may include mismatches between long and short positions by maturity or by issuer; and

(c) the AI should ensure that its internal models capture concentration risk that may arise in a portfolio that is not diversified.

2.7.7 Where specific risk is also modelled by an AI, it is important for the AI to conduct more extensive model validation and demonstrate that it satisfies the criteria for specific risk modelling set out in subsection 4.2.

[11] Testing of sub-portfolios may be applicable to an AI which classifies its market risk exposures into sub-portfolios in accordance with the risk categories (e.g. interest rate risk and foreign exchange risk) or characteristics of these exposures.

2.8 Stress-testing

2.8.1 An AI should have a comprehensive stress-testing programme for conducting regular stress tests to supplement the AI's risk analyses based on the daily output of its internal models (see Annex C for more details).

2.8.2 The results generated by an AI's stress-testing programme should be reported routinely to the AI's senior management and periodically to the AI's Board (or a committee with delegated authority from the Board).

2.8.3 The stress-testing results should also be taken into account in -

- setting the AI's market risk management policies (including trading and market risk exposure limits); and

- performing an assessment of the adequacy of the AI's regulatory capital and internal capital for market risk and the AI's ability to withstand any future events, or changes in market conditions, that could have adverse effects on the AI's market risk exposures (see section C6 of Annex C for more details).

2.8.4 Where stress tests reveal to an AI any particular vulnerability to a given set of circumstances, the AI should take prompt measures (e.g. by means of hedging or downsizing its market risk exposures or increasing its capital level) to manage those risks appropriately.

2.9 Independent review or audit

2.9.1 An independent review or audit of an AI's compliance with the requirements specified in Schedule 3 to the Rules should be conducted regularly by the AI's internal auditors or by independent external parties which are qualified to do so.

2.9.2 Such review or audit should include the activities of an AI's trading and market risk control units. A review of the AI's market risk management system should take place regularly (not less than once a year) and should specifically address, at a minimum, the following areas:

- the adequacy of documentation of the AI's market risk management system (including its internal models);
- the organisation of the AI's market risk control unit;
- the integration of the AI's market risk measures into daily risk management;
- the AI's approval process for pricing models and valuation methods used by its front- and back-office units;
- the validation of any significant change in the AI's market risk management system;
- the scope of market risk captured by the AI's internal models;
- the integrity of the AI's management information system;
- the accuracy, timeliness and completeness of position data;
- the verification of the consistency, timeliness and reliability of data sources used to run the AI's internal models, including the independence of data sources;
- the accuracy and appropriateness of volatility and correlation assumptions;
- the accuracy of valuation and risk measures calculations; and

- the verification of the accuracy of the AI's internal models by reviewing -

  (a) the results of internal validation as required in subsection 2.7; and

  (b) the quarterly back-testing results as described in Annex B.

3. Quantitative criteria

3.1 General

3.1.1 The quantitative criteria set out in this section apply mainly to AIs which calculate VaR and stressed VaR, and (where applicable) incremental risk charge and/or comprehensive risk charge using internally developed models.

3.1.2 As no particular types of internal model are prescribed by the MA, an AI has flexibility to devise its own internal models, an example of which is the calculation of VaR based on variance-covariance matrices, historical simulations or Monte Carlo simulations, as long as the models can capture all material factors affecting the market risk faced by the AI (see subsection 2.4).

3.2 Minimum criteria

VaR and stressed VaR

3.2.1 VaR should be calculated by an AI on a daily basis, and stressed VaR at least on a weekly basis.

3.2.2 A one-tailed 99% confidence interval should be used by an AI in calculating VaR and stressed VaR.

3.2.3 The minimum holding period used by, or assumed by, an AI's internal models for its portfolio of exposures should be 10 trading days. The AI may use VaR and stressed VaR calculated by its internal models according to a shorter holding period scaled up to 10 days by, for example, the square root of time (see para.

3.2.9 for the treatment of option positions). An AI using this scaling approach must demonstrate periodically the reasonableness of the approach in the circumstances of the AI to the satisfaction of the MA.

3.2.4 The historical observation period for calculating VaR should not be less than one year (i.e. 250 trading days). If an AI applies a weighting scheme to the historical observations for the calculation of VaR, a higher weighting should be assigned to recent observations such that the effective observation period would be at least one year (i.e. the weighted average time lag of the individual historical observations cannot be less than six months). However, an AI must not apply a weighting scheme to the historical observations for the calculation of stressed VaR.

3.2.5 An AI may calculate VaR using a weighting scheme that is not fully consistent with the requirements set out in para. 3.2.4 only if that scheme results in a market risk capital charge that is not lower than that which would be calculated by the use of a scheme that fully complies with the requirements in para. 3.2.4.

3.2.6 An AI should be able to use a shorter historical observation period for the calculation of VaR (but not stressed VaR) if the MA requests the AI to do so on the ground that, in the opinion of the MA, this is justified due to a significant increase in volatility in the price of the AI's portfolio of exposures (e.g. collapse in stock market).

3.2.7 An AI should update the data used at least once every month and reassess them whenever market prices are subject to material changes. This updating process should be flexible enough to allow for more frequent updates where necessary.

3.2.8 An AI's internal models may recognise empirical correlations of factors affecting market risk within and across its risk categories, provided that the AI's system for identifying and measuring correlations is effective and implemented in a prudent manner.

3.2.9 An AI's internal models should accurately capture the unique risks associated with option positions within each of the risk categories and, in particular -

- the AI's internal models should be able to capture the non-linear price characteristics of the option positions (e.g. gamma risk);

- the AI is expected to apply a full 10-day movement in price to its option positions or positions that display option-like characteristics in calculating VaR and stressed VaR. However, if the AI is unable to do so, it should be able to use other methods (e.g. periodic simulation or stress-testing) to adjust its market risk capital charge for such positions;

- the AI's internal models should have a set of risk factors that capture the volatilities of the rates and prices of the AI's option positions, i.e. vega risk; and

- if the AI's portfolio of options is relatively large or complex, there should be detailed specifications of the relevant volatilities. This means that the AI should measure the volatilities of its option positions at different maturities.

Stressed VaR – Additional requirements

3.2.10 The stressed VaR measure is intended to replicate a VaR calculation that would be generated on an AI's current market risk portfolio if the relevant market factors were experiencing a period of stress. No particular model is prescribed for the calculation of stressed VaR. An AI should use appropriate techniques to translate its VaR model into one that delivers a stressed VaR, with model inputs calibrated to historical data from a continuous 12-month period of

significant financial stress relevant to its portfolio[12] (i.e. the "stressed VaR relevant period"). For example, an AI should consider applying anti-thetic [13] data, or absolute rather than relative volatilities, to deliver an appropriate stressed VaR.

3.2.11 An AI should determine an appropriate stressed VaR relevant period for the portfolios included in its stressed VaR calculations. For example, a 12-month period relating to significant losses arising from the 2008/2009 Global Financial Crisis or the 1997/1998 Asian Financial Crisis may adequately reflect a period of such stress. Other periods relevant to an AI's current portfolio should also be considered.

3.2.12 An AI should seek the MA's prior consent for using a stressed VaR relevant period in respect of any portfolio included in its stressed VaR calculations. The AI should also regularly review, at least annually, the continued appropriateness and relevance of any stressed VaR relevant period adopted for the calculations.

Incremental risk charge and comprehensive risk charge

3.2.13 The incremental risk charge and comprehensive risk charge complement other enhancements to the Basel II market risk framework to address perceived shortcomings of VaR models, which notably ignore differences in the underlying liquidity of trading book positions. Also, because of the use of a short holding period in the 2006 framework (usually a one-day VaR scaled up to 10 days), the VaR measure may not fully

[12] As the stressed VaR measure is intended to deliver the change that the AI's current VaR model would generate under a period of financial stress relevant to its portfolio, the time-series data upon which the stressed VaR is calculated should be stable.

[13] Anti-thetic in this context means that price movements are considered relevant irrespective of their direction. For example, if a time series included a significant upward spike in equity prices, the model could apply significant movements in equity prices both upwards and downwards. This might be particularly relevant if an AI's portfolio is the "right way" to a period of financial stress (i.e. long equities in a period of stock market surge); the model used should reflect that open risk positions (in either direction) are vulnerable to stressed variables.

reflect large daily losses that occur less frequently as well as the potential for large cumulative price movements over longer periods, and may risk producing insufficient regulatory capital for market risk following periods of relative calm in financial markets.

3.2.14 Subject to the prior approval of the MA, an AI should have an internally developed approach (or approaches) for calculating incremental risk charge or comprehensive risk charge, or both, in respect of exposures subject to such charges.

3.2.15 For the calculation of incremental risk charge or comprehensive risk charge, an AI —

- must comply with the requirements specified in Schedule 3 of the Rules applicable to or in relation to the AI, as well as the requirements set out in Annex D (for incremental risk charge) or Annex E (for comprehensive risk charge);

- must incorporate the relevant positions in the AI's calculation of VaR and stressed VaR; and

- must not make any adjustment for double-charging of capital between the incremental risk charge and the comprehensive risk charge, or among the two capital charges and other market risk capital charges, applicable to those positions.

3.2.16 An AI must calculate incremental risk charge or comprehensive risk charge, or both, at least once a week, or more frequently as required by the MA.

3.2.17 Incremental risk charge should be measured at the 99.9% confidence interval over a capital horizon of one year, taking into account the liquidity horizons applicable to individual positions or sets of positions. Losses caused by broader market-wide events affecting multiple issues or issuers are encompassed by this formulation. The measurement of comprehensive risk charge should follow the same approach.

3.2.18 For the purposes of para. 3.2.17 –

- "capital horizon" is defined as the time period over which default risk and credit migration risk are measured; and

- "liquidity horizon" is defined as the time required to sell the position, or to hedge all material risks covered by the internal model that an AI uses to calculate incremental risk charge, in a stressed market, and is subject to a floor of three months.

3.2.19 The MA may, by notice in writing given to an AI, impose a supplemental capital charge against a correlation trading portfolio of the AI, to be added to the AI's comprehensive risk charge calculated under its internally developed approach, if the MA is satisfied that the stress-testing results referred to in subsections E2.4 to E2.6 of Annex E indicate a material shortfall in the AI's comprehensive risk charge.

3.2.20 Annex E further provides guidance on the factors for assessing the materiality of the shortfall in the AI's comprehensive risk charge, and if the MA is satisfied that there is a material shortfall in an AI's comprehensive risk charge, the factors that the MA would consider in determining whether, and the extent to which, a supplemental capital charge should be imposed on the AI. Such guidance is set out in subsections E2.7 and E2.8 respectively.

3.3 Calculation of market risk capital charge

3.3.1 Pursuant to §317(3) to (7) of the Rules, an AI's internal models should be able to calculate, on a daily basis, the market risk capital charges applicable to the AI in the following manner:

- VaR is derived as the higher of -

  (a) the AI's VaR for the risk categories applicable to its internal models as at the last trading day; or

(b) the AI's average VaR for the last 60 trading days multiplied by a multiplication factor, m_c, as determined under §319(1) of the Rules (see para. 3.4.1);

- stressed VaR is derived as the higher of -

  (a) the AI's latest available stressed VaR for the risk categories applicable to its internal models; or

  (b) the AI's average stressed VaR for the last 60 trading days multiplied by a multiplication factor, m_s, as determined under §319(4) (see para. 3.4.1);

- incremental risk charge is derived by applying a scaling factor, S_i, as determined under §319(5) (see para. 3.4.3), to the higher of –

  (a) the AI's latest available incremental risk charge for the risk categories applicable to its internal models; or

  (b) the AI's average incremental risk charge for the last 12 weeks; and

- comprehensive risk charge is derived as the higher of –

  (a) the comprehensive risk charge calculated by applying a scaling factor, S_c, as determined under §319(6) (see para. 3.4.3) to the higher of –

    (i) the AI's latest available comprehensive risk charge; or

    (ii) the AI's average comprehensive risk charge for the last 12 weeks; or

  (b) 8% of the AI's market risk capital charge for specific risk for its correlation trading

portfolio calculated under the STM approach according to §287B of the Rules.

3.3.2 Pursuant to §317(1), an AI must calculate the risk-weighted amount for market risk under the IMM approach as the sum of –

- the market risk capital charge for general market risk calculated by the AI's internal model expressed as VaR;
- the market risk capital charge for general market risk calculated by the AI's internal model expressed as stressed VaR;
- where applicable, the market risk capital charge for specific risk calculated by the AI's internal model expressed as VaR (except that the AI need not capture the default risk and credit migration risk of positions that are subject to incremental risk charge);
- where applicable, the market risk capital charge for specific risk calculated by the AI's internal model expressed as stressed VaR (except that the AI need not capture the default risk and credit migration risk of positions that are subject to incremental risk charge);
- where applicable, the incremental risk charge calculated by the AI's internal model;
- where applicable, the comprehensive risk charge calculated by the AI's internal model; and
- where applicable, the supplemental capital charge referred to in §318(3) in respect of specific risk interest rate exposures which fall within the AI's correlation trading portfolio,

multiplied by 12.5.

3.3.3 Where an AI uses more than one internal model to calculate market risk capital charge for general market risk and market risk capital charge for specific risk, the AI must comply with individual sub-paragraphs under para. 3.3.1 that are applicable to it, except that the sub-paragraph or sub-paragraphs concerned must be applied separately to the relevant market risk capital charge generated from each model.

3.3.4 An AI must use the STM approach to calculate the market risk capital charge for specific risk for the following exposures in its trading book :

- securitization exposures and n^{th}-to-default credit derivative contracts that do not fall within a correlation trading portfolio;

- specific risk interest rate exposures that are subject to an incremental risk charge but for which the MA's approval to calculate this charge has not been obtained; and

- exposures within a correlation trading portfolio but for which the MA's approval to calculate a comprehensive risk charge has not been obtained.

3.3.5 An AI that is subject to para. 3.3.4 may however seek the MA's approval to also calculate VaR and stressed VaR for specific risk for their exposures that fall within the first bullet of para. 3.3.4. The VaR and stressed VaR so calculated will be above, and on top of, the AI's market risk capital charge for specific risk calculated under the STM approach for those exposures.

3.3.6 An AI must not exclude, for the purposes of calculating the market risk capital charge for its positions in foreign exchange (including gold) and exchange rate-related derivative contracts, any of its structural positions (within the meaning of §295(3) of the Rules) from the calculation except after consultation with the MA.

3.4 Multiplication and scaling factors

3.4.1 The multiplication factors, m_c and m_s, to be used by an AI are respectively the sum of -

- the value of three;
- a plus factor, ranging from zero to one, assigned to the AI in accordance with the number of back-testing exceptions during the last 250 trading days in respect of VaR (but not stressed VaR) as set out in the table under subsection B3.2 of Annex B; and
- any additional plus factor which may be assigned to the AI on the basis of its compliance with Schedule 3 of the Rules. For example, the MA may assign such a factor if he is satisfied that the AI has ceased to comply fully with the qualitative criteria set out in section 2 after being granted an approval to use the IMM approach to calculate its market risk.

3.4.2 In other words, an AI may have a multiplication factor of three for m_c or m_s only if the AI complies fully with Schedule 3 of the Rules and its back-testing results in respect of VaR are satisfactory (i.e. the number of back-testing exceptions during the last 250 trading days is fewer than five). Also, the m_c and m_s to be used by an AI will be the same only if any additional plus factor assigned by the MA for calculating VaR and that for calculating stressed VaR are the same.

3.4.3 The scaling factors to be used by an AI for calculating incremental risk charge (S_i) and comprehensive risk charge (S_c) should be one or such other value as the MA may specify in a notice in writing given to the AI.

4. Specific risk

4.1 General

4.1.1 An AI may calculate its market risk capital charge for specific risk for interest rate exposures (other than securitization exposures and n^{th}-to-default credit derivative contracts) and equity exposures using internal models if –

- the AI has a VaR measure and a stressed VaR measure that incorporate specific risk for such exposures; and
- the MA has determined that the AI meets all the applicable qualitative and quantitative criteria set out in sections 2 and 3 respectively, as well as additional criteria for specific risk set out in this section that are applicable to such exposures.

4.1.2 Where an AI's internal models for specific risk are unable to meet the above-mentioned criteria, the AI should use the STM approach to calculate its market risk capital charge for specific risk.

4.2 Minimum criteria

4.2.1 In order to meet the criteria for modelling of specific risk, an AI's internal models should capture all material components of market risk[14] and be responsive to changes in market conditions and the composition of the AI's portfolios of exposures. In particular, the AI's internal models should -

- be capable of providing a justification for the historical price variation in the AI's portfolios[15];

[14] AIs need not capture default and credit migration risks for positions subject to incremental risk charge.

[15] The key ex-ante measures of model quality are "goodness-of-fit" measures which address the question of how much of the historical variation in price value is explained by the risk factors included within the AI's internal model. One measure of this type which can often be used is an R-squared measure from regression methodology. If this measure is to be used, the risk factors included in the AI's internal model would be expected to be able to explain a high percentage, such

- be sensitive to changes in portfolio construction and result in a higher market risk capital charge for portfolios which have increased concentration in particular issuers, entities or sectors of exposures;

- be able to signal rising market risk in an adverse environment[16];

- be sensitive to name-related basis risk, that is, the material idiosyncratic differences between similar but not identical positions (e.g. debt securities with different levels of subordination and maturity mismatches, and credit derivative contracts with different credit events);

- be able to capture market risk which arises from events, other than market-wide shocks resulting in large changes in prices; and

- be validated through back-testing aimed at assessing whether specific risk is being captured adequately (see subsection 4.3).

4.2.2 An AI's internal models should prudently assess the market risk arising from less liquid positions and positions with limited price transparency under realistic market scenarios. Proxies may be used only if -

- available data are insufficient or are not reflective of the true volatility of an exposure or a portfolio of exposures; and

- such proxies are prudent.

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as 90%, of the historical price variation or the AI's internal model should explicitly include estimates of the residual variability not captured in the factors included in this regression. For some types of internal models, it may not be feasible for the AI to calculate a goodness-of-fit measure. In such cases, the AI is expected to work with the MA to define an acceptable alternative measure which would meet this regulatory objective.

[16] This could be achieved by incorporating in the historical estimation period of the AI's internal model at least one full credit cycle and ensuring that the AI's internal model would not have been inaccurate in the downward portion of the cycle. Another approach for demonstrating this is through simulation of historical or plausible worst-case environments.

4.2.3 As modelling techniques and best practices evolve, an AI should avail itself of these advances.

4.3 Back-testing requirements

4.3.1 An AI which applies modelled estimates of specific risk is required to conduct back-testing aimed at assessing whether specific risk is being adequately captured.

4.3.2 The methodology an AI should use for validating its specific risk estimates is to perform separate back tests on sub-portfolios using daily data on sub-portfolios subject to specific risk. The key sub-portfolios for this purpose are generally trading book positions in debt securities and equities. If, however, the AI classifies its trading book positions into finer categories (e.g. emerging markets), it is appropriate for the AI to use such categorisation for sub-portfolio back-testing purposes. The AI should also maintain and use such sub-portfolio structure consistently unless it can demonstrate that there are valid grounds to change the structure.

4.3.3 An AI is required to have a process to analyse exceptions identified through the back-testing of specific risk. This process is intended to serve as the fundamental way in which the AI corrects its internal models of specific risk in the event they become inaccurate. There will be a presumption that the AI's internal models which incorporate specific risk are "unacceptable" if the results at the sub-portfolio level produce a number of exceptions commensurate with the "red zone" as defined in section B3 of Annex B.

4.3.4 An AI with "unacceptable" specific risk models is expected to take prompt actions to address and remedy the problems identified with the models and ensure that there is a sufficient capital buffer to absorb the risk that the AI's internal models could not adequately capture.

4.3.5 See Annex B for more details of the required back-testing framework and the MA's approach to interpreting AIs' back-testing results.

5. Model review

5.1 Acceptance criteria

5.1.1 In reviewing an AI's internal models, the MA will require assurance that:

- the internal validation (see subsection 2.7) and independent review or audit (see subsection 2.9) are conducted in a satisfactory manner;
- the formulae used in the AI's calculation process as well as for the pricing of the AI's option positions and other complex instruments are validated by qualified parties which are independent of the AI's trading functions (see para. 2.7.2);
- the complexity and structure of the AI's internal models are appropriate with regard to the AI's portfolio of exposures;
- the AI's internal models provide a reliable measure of potential losses over time by reviewing the results of the AI's back-testing, e.g. by comparing the daily VaR measures with actual profits and losses of the AI's portfolio of exposures; and
- data flows and processes associated with the AI's internal models are transparent and accessible. In particular, it is essential that the MA should have easy access, whenever considered necessary, to the model's specifications and parameters.

5.2 Portfolio testing

5.2.1 From time to time, the MA may require an AI using internal models to participate in a portfolio testing exercise. The test portfolios will generally be determined by the MA.

5.2.2 The portfolio testing exercise will serve as a peer group comparison among AIs using internal models and the results of such exercise will form part of the MA's continuing assessment of the accuracy and reliability of individual AIs' internal models.

5.3 Recognition of internal models

5.3.1 Where an AI makes an application under §18(1) of the Rules, the model review process conducted by the MA will entail at least one on-site visit before any internal model, which is the subject of the AI's application, is recognised by the MA for the purposes of calculating the AI's market risk capital charge.

5.3.2 Under §18(4) of the Rules, any significant change to an AI's internal model, which has been recognised by the MA and is the subject of his approval under §18(2)(a) of the Rules, requires the MA's prior consent.

5.3.3 An AI should regularly inform the MA of the results of its internal validation (e.g. back-testing results). The MA uses such information as a basis to determine whether a higher multiplication factor should be assigned to the AI concerned or whether the AI's internal models remain acceptable to calculate market risk for capital adequacy purposes.

5.3.4 The scope and extent of the MA's model review will vary, depending on, but not limited to, the following factors:

- whether the AI's internal models are used to calculate general market risk, specific risk or both;
- when the AI's internal models were last validated by the MA;
- whether there have been any significant changes to the AI's internal models since the last validation;

- the number of back-testing exceptions arising from the AI's internal models during the last 250 trading days; and

- any major findings relating to the AI's market risk management system identified by the MA or by the AI's external or internal auditors.

Annex A: Specification of market risk factors

A1. General

A1.1 It is important for an AI's internal models to contain an appropriate set of market risk factors, i.e. the market rates and prices that affect the value of the AI's market risk exposures, which are sufficient to capture the risks inherent in these market risk exposures. Although the AI may have some discretion in specifying the risk factors for its internal models, the guidelines set out in this Annex should be observed.

A2. For interest rates

A2.1 An AI's internal models should incorporate risk factors corresponding to interest rates in each currency in which the AI holds significant trading book positions[17] which are interest rate sensitive.

A2.2 An AI's internal models should model a yield curve using one of the generally accepted approaches, e.g. by estimating the forward rates of zero coupon yields. The yield curve should be divided into various maturity segments in order to capture variations in the volatility of interest rates along the yield curve. There will typically be one risk factor corresponding to each maturity segment (e.g. one month, three months, six months and one year).

A2.3 For material exposures to interest rate movements in the major currencies and markets, an AI should model the yield curve using a minimum of six risk factors. The number of risk factors used, however, should ultimately be driven by the nature of the AI's trading strategies. For instance, if an AI engages in complex arbitrage strategies or if an AI's portfolio of exposures comprises

[17] The AI should have a set of risk factors for each currency accounting for 5% or more of its trading book positions.

various types of securities across many points of the yield curve, the AI's internal models should have a greater number of risk factors in order to capture its interest rate risk more accurately.

A2.4 An AI's internal models should incorporate separate risk factors to capture spread risk (e.g. between bonds and swaps). A variety of approaches may be used to capture the spread risk arising from less than perfectly correlated movements between the interest rates of sovereigns and other fixed-income instruments, such as specifying a completely separate yield curve for non-sovereign fixed-income instruments (e.g. swaps or municipal securities) or estimating the spread over sovereign interest rates at various points along the yield curve.

A3. For equity prices

A3.1 An AI's internal models should incorporate risk factors corresponding to each of the equity markets in which the AI holds significant positions.

A3.2 At a minimum, there should be a risk factor that is designed to capture market-wide movements in equity prices (e.g. a market index). Positions in individual equities or in sector indices can be expressed in "beta equivalents" [18] relative to this market-wide index.

A3.3 A more detailed approach is to have risk factors corresponding to various sectors of the overall equity market (e.g. industry sectors or cyclical and non-cyclical sectors). As mentioned above, positions in individual equities within each sector can be expressed in beta equivalents relative to the sector index.

A3.4 The most extensive approach is to have risk factors corresponding to the volatility of individual equities.

[18] A "beta equivalent" position can be calculated from a market model of equity price returns (such as the CAPM model) by regressing the return on the individual equity or sector index on the risk-free rate of return and the return on the market index.

A3.5 The sophistication and nature of the modelling technique for a given equity market should correspond to the AI's overall exposures to the market as well as its concentration on individual equities in that market.

A4. For exchange rates (including gold)

A4.1 An AI's internal models should incorporate risk factors corresponding to individual foreign currencies in which the AI's positions are denominated. Since the VaR measures generated by the AI's internal models are expressed in the AI's domestic currency, any net position denominated in a foreign currency will give rise to foreign exchange risk. Thus, the AI's internal models should incorporate risk factors corresponding to the exchange rate between the AI's domestic currency and each foreign currency in which the AI has a significant position.

A5. For commodity prices

A5.1 An AI's internal models should incorporate risk factors corresponding to each of the commodities in which the AI holds significant positions.

A5.2 It is acceptable for AIs with relatively limited positions in commodities to have a straightforward specification of risk factors. Such a specification would likely entail one risk factor for each commodity price to which the AI is exposed. In cases where the AI's aggregate positions are small, it may be acceptable for the AI to use a single risk factor for a relatively broad sub-category of commodities (e.g. a single risk factor for all types of oil).

A5.3 The internal models of an AI with more active trading in commodities should encompass -

- directional risk to capture the exposure from changes in spot prices arising from net open positions;

- forward gap and interest rate risk to capture the exposure to changes in forward prices arising from maturity mismatches; and

- basis risk to capture the exposure to changes in the price relationships between two similar but not identical commodities.

In addition, the models should take account of variation in the "convenience yield" [19] between derivative positions (such as forward contracts and swaps) and cash positions in the commodity.

[19] The convenience yield reflects the benefits from direct ownership of the physical commodity (e.g. the ability to profit from temporary market shortages) and is affected both by market conditions and by factors such as physical storage costs.

Annex B: Use and interpretation of back-testing results

B1. General

B1.1 This Annex describes the framework for incorporating back-testing into the IMM approach to the calculation of an AI's market risk and elaborates upon the supervisory approach to interpreting the AI's back-testing results, with particular focus on the VaR measure. The principles may be similarly extended to the back-testing of other market risk capital measures as appropriate.

B1.2 The process whereby an AI routinely compares its daily profits and losses with model-generated risk measures to gauge the accuracy and reliability of its internal models is known as back-testing.

B1.3 The essence of back-testing, as set out in this Annex, is the daily comparison of an AI's actual trading results with the VaR measures generated by the AI's internal models. If this comparison reveals limited differences, the back-testing raises no concern regarding the quality of the internal models. In some cases, however, the comparison may uncover significant differences, indicating likely problems with the internal models or the assumptions of the back tests. In between these two situations is a grey area where the back-testing results are, on their own, inconclusive.

B1.4 In considering how to incorporate the back-testing results more realistically into the IMM approach, the MA acknowledges that AIs may perform different types of back-testing comparisons and use different standards to interpret the comparison results and the concerns over the imperfect nature of the signals generated by back-testing.

B2. Description of back-testing framework

B2.1 Back-testing programmes comprise a periodic comparison of an AI's daily VaR measures with the subsequent daily profits or losses ("trading outcomes").

The VaR measures are intended to be larger than all but a certain fraction of the trading outcomes, where that fraction is determined by the confidence interval of the VaR measures. Comparing the VaR measures with the trading outcomes means that the AI counts the number of times the VaR measures were larger than the trading outcomes. The fraction covered can then be compared with the intended level of coverage to gauge the performance of the AI's internal models.

B2.2 The back tests applied by an AI compare whether the observed percentage of trading outcomes covered by the VaR measures is consistent with the assumption of a 99% confidence interval. That is, these tests attempt to determine if the AI's 99% VaR measures truly cover 99% of its trading outcomes.

B2.3 The regulatory back-testing framework adopted by the MA requires the comparison of an AI's daily trading outcomes with its VaR measures calibrated on a one-day holding period. This one-day requirement differs from the quantitative criterion stated in para. 3.2.3 (i.e. a 10-day holding period). This is aimed at reducing any possible contamination arising from changes in an AI's portfolio composition during the holding period which will be reflected in its actual trading outcomes but not in its VaR measures which assume a static portfolio.

B2.4 The concern about contamination of the trading outcomes is relevant, however, even for one-day trading outcomes[20]. A more sophisticated approach to deal with this may involve a detailed attribution of trading outcomes by source, including fees, spreads, market movements and intra-day trading results. In such a case the VaR measures can then be compared with the outcomes arising from market movements alone.

[20] There is a concern that the overall one-day trading outcome is not a suitable point of comparison because it includes the effects of intra-day trading, possibly including fee income. In addition, intra-day trading will tend to increase the volatility of trading outcomes and may result in cases where the overall trading outcome exceeds the VaR measures.

B2.5 To the extent that the back-testing programme is viewed purely as a statistical test of the integrity of the calculation of VaR measures, it is essential to employ a definition of daily trading outcome that allows for an uncontaminated test. To achieve this, an AI should develop the capability to perform back tests based on the hypothetical changes in portfolio value that would occur were end-of-day positions to remain unchanged during the holding period (say one day).

B2.6 Back-testing using actual daily trading outcomes is also a useful exercise because it can uncover cases where the VaR measures do not accurately capture trading volatility in spite of such measures being calculated with integrity.

B2.7 For these reasons, the MA encourages every AI to develop the capability to perform back tests using both hypothetical (i.e. using changes in portfolio value that would occur were end-of-day positions to remain unchanged) and actual trading (i.e. excluding fees, commissions and net interest income) outcomes. Each approach has its own value. In combination, the two approaches are likely to provide a stronger understanding of the relation between VaR measures and trading outcomes.

B2.8 The regulatory back-testing framework entails formal testing and the counting of the number of exceptions (i.e. the instances in which daily trading losses in a portfolio of exposures are above the daily VaR measures generated by an internal model) on a quarterly basis using the most recent 12 months of data. For example, over 200 trading days, a 99% daily VaR measure should cover, on average, 198 of the 200 trading outcomes, leaving two exceptions.

B2.9 An AI must not, without the prior consent of the MA, make any significant changes to the approach it uses to determine the number of back-testing exceptions.

B2.10 Using the most recent 12 months of data yields approximately 250 daily observations for back-testing

purposes. The MA will use the number of exceptions (i.e. out of 250) identified in respect of an AI's internal models as the basis for a supervisory response which, in serious cases, means that the MA may require the AI to hold additional capital by means of the supervisory review process (see CA-G-5 "Supervisory Review Process") or disallow the AI from continuing using the IMM approach to calculate its market risk for capital adequacy purposes.

B2.11 The formal implementation of an AI's back-testing programme should begin on the date that the AI starts using the internal models approved by the MA for calculating its market risk capital charge. This implies that the first formal counting of exceptions under the AI's back-testing programme will occur 12 months later. This, however, does not preclude the MA from requesting the AI to provide its back-testing results prior to that date and using such results as part of the MA's initial assessment of the robustness of the AI's internal models.

B2.12 Once an AI's internal models are approved by the MA for the purposes of the IMM approach, the MA will monitor the AI's back-testing results on a quarterly basis through data collected in Part IV of the "Return of Capital Adequacy Ratio of an Authorized Institution Incorporated in Hong Kong - MA(BS)3(IV)".

B3. Three zone approach

B3.1 With the statistical limitations of back-testing in mind, the MA has established a framework for the interpretation of back-testing results that encompasses a range of possible supervisory responses, depending on the strength of the signal generated from the back tests. These responses are classified into three zones:

- the green zone corresponds to a level of exceptions in back-testing results that do not suggest a problem with the quality of an internal model;

- the yellow zone encompasses results that raise questions on the quality of an internal model but where there is no definitive conclusion as to the existence of a problem with the quality of the model; and

- the red zone corresponds to a back-testing result that almost certainly indicates a problem with an internal model.

B3.2 The table below sets out the boundaries of these three zones and the presumptive supervisory response for each back-testing outcome, based on a sample of 250 observations. Where the back-testing results indicate weaknesses in an internal model, it should be presumed that the minimum multiplication factor of three will be increased by adding a plus factor (see subsection 3.4) as shown below (but see subsection B3.8).

Zone	Number of exceptions out of 250 observations	Plus factor
Green zone	Less than 5	0.00
Yellow zone	5	0.40
	6	0.50
	7	0.65
	8	0.75
	9	0.85
Red zone	10 or more	1.00

B3.3 The back-testing results for calculating the plus factor are based only on the measure of VaR (but not stressed VaR).

Green zone

B3.4 The green zone comprises the range of zero to four exceptions.

B3.5 Since an internal model that truly provides 99% coverage is quite likely to produce as many as four exceptions in a sample of 250 observations, there is little reason for concern raised by a back-testing result that falls within this range. In such a case, the minimum multiplication factor of three will be applied to both VaR and stressed VaR measures generated by the internal model, provided that the AI complies fully with all the qualitative criteria set out in section 2.

Yellow zone

B3.6 The yellow zone comprises the range of five to nine exceptions.

B3.7 Outcomes in this range are plausible for both accurate and inaccurate models, although they are generally more likely for inaccurate models than for accurate models. Moreover, the presumption that an internal model is inaccurate should grow as the number of exceptions increases in the range from five to nine. As such, it is justifiable for the MA to apply a higher plus factor to an AI in accordance with the table in subsection B3.2 if the AI's back-testing results have a higher number of exceptions in the yellow zone.

B3.8 It should be stressed, however, that such increases in the plus factor are not meant to be purely automatic. The results in the yellow zone do not always imply an inaccurate model and it is not the MA's intent to penalise any AI solely for bad luck. Nevertheless, back-testing results falling within the yellow zone will generally cause an AI to attract a higher plus factor unless the AI can prove to the satisfaction of the MA that the model in use is fundamentally sound and the exceptions are temporary.

B3.9 There are many different types of information an AI may provide to the MA to prove that a higher multiplication factor may not be warranted. For example, an AI engaging in regular back-testing programmes may disaggregate its back-testing results by breaking up its overall trading portfolio into trading units organised by risk factors or product categories. Disaggregating in this fashion could allow the tracking of a problem that surfaced at the aggregate level back to its source at the level of a specific trading unit or model. The AI may also implement back-testing for confidence intervals other than 99% or perform other statistical tests as mentioned in para. 2.7.6 to prove the accuracy and reliability of its internal models.

B3.10 Further, an AI should document all of the exceptions generated from its ongoing back-testing programme (including explanation for the exceptions) and categorise them according to the types of explanation (see section B4). This process is useful for the MA to determine an appropriate supervisory response (see section B5).

Red zone

B3.11 The red zone comprises ten or more exceptions.

B3.12 In contrast to the yellow zone, where the MA may exercise judgement in interpreting the back-testing results, outcomes in the red zone should automatically lead to a presumption that a problem exists with an AI's internal model. It is extremely unlikely that an accurate model would independently generate ten or more exceptions from a sample of 250 observations. In general, therefore, if an internal model falls within the red zone, the MA will generally increase the multiplication factor by adding a plus factor of one (i.e. increasing the multiplication factor from three to four).

B3.13 The MA will also perform on-site examinations to investigate the reasons why the internal model produced such a large number of exceptions and require the AI concerned to take immediate actions to

remedy deficiencies with the model. In the case of a severe problem with the basic integrity of an internal model, the MA may disallow the AI from continuing to use the IMM approach to calculate its market risk for capital adequacy purposes and require the AI to adopt the STM approach instead (also see subsection B5.2).

B3.14 Although ten exceptions is a significantly high number for a sample of 250 observations, there could on very rare occasions be a valid reason for an accurate model to produce so many exceptions (see subsection B4.4). In particular, when financial markets are subject to a major regime shift, many volatilities and correlations are expected to shift substantially as well. Any AI using an internal model is expected to update the volatility and correlation estimates underlying the model very promptly in this situation; otherwise such a regime shift could generate a number of exceptions in a short period of time. In essence, however, these exceptions would all be occurring for the same reason and therefore the appropriate supervisory response might not be the same as when there were ten exceptions but each from a separate incident. One possible supervisory response in this instance would simply be to require the AI to take account of the regime shift in its internal model as quickly as it can while maintaining the integrity of its procedures for updating the model.

B3.15 It should be stressed, however, that this supervisory response will only be given under extraordinary circumstances. In most cases, the MA will automatically increase an AI's multiplication factor to the value of four.

B4. Reasons for exceptions

B4.1 Exceptions will generally fall into the following four categories:

- flaws in the basic integrity of a model (see subsection B4.2);

- the model's accuracy requiring improvement (see subsection B4.3);

- markets move in a fashion unanticipated by the model (see subsection B4.4); and

- intra-day trading (see subsection B4.5).

B4.2 Samples of exceptions arising from flaws in the basic integrity of a model include -

- the AI's market risk management system is not able to capture the risk of the positions, e.g. the positions are being reported incorrectly; or

- model volatilities or correlations are calculated incorrectly, e.g. the computer erroneously calculates daily model volatilities on a 280-day basis when it should be on a 250-day basis.

B4.3 An example of an inaccuracy in a model that may cause exceptions is that the model is not able to assess the risk of some instruments with sufficient precision, e.g. too few maturity buckets or a spread omitted.

B4.4 Reasons for exceptions resulting from unanticipated market movements include -

- random chance (i.e. a very low probability event);

- markets moved by more than the model predicted was likely, i.e. volatility was significantly higher than expected; or

- markets did not move together as expected, i.e. correlations were significantly different from those assumed by the model.

B4.5 Intra-day trading can cause exceptions, e.g. where there is a large change in an AI's positions causing losses or income-earning events between the end of the first day (when the risk estimate was calculated)

and the end of the second day (when trading results were tabulated).

B5. Consideration of explanations and factors by the MA

B5.1 In general, problems relating to the basic integrity of an internal model are potentially the most serious. If exceptions are attributable to this category for a particular trading unit in the AI concerned, the plus factor should apply. In addition, the internal model may be in need of substantial review or adjustment. For serious cases, the MA may disallow the AI from continuing to use the IMM approach to calculate its market risk for capital adequacy purposes until appropriate corrections are undertaken by the AI, and require the AI to adopt the STM approach instead.

B5.2 In the event that the MA disallows an AI from continuing to use the IMM approach and requires the AI to adopt the STM approach instead due to major deficiencies in its internal models (e.g. see paragraphs B3.13 and B5.1 above) -

- the AI would be given a reasonable period to make the transition from the IMM approach to the STM approach, having regard to its specific circumstances (including the severity and possible impact of the deficiencies in its internal models); and

- in the interim period during which the AI continues to use any deficient internal model for market risk calculation, the MA may require the AI to adopt, or may impose on the AI, risk-mitigating measures to ensure the adequacy of its market risk capital. These measures might include, for example, an increase in multiplication or scaling factors, the imposition of capital floors, and/or an increase in capital ratio under Pillar 2, as well as other appropriate prudential supervisory measures (such as temporary restrictions on the AI's market risk activities or its level of market risk exposures).

B5.3 The second category of problem, i.e. the model's accuracy requiring improvement, is one that can be expected to occur at least part of the time with most risk measurement models. No model can hope to achieve infinite precision as all models involve a certain degree of approximation. If, however, a particular model used by an AI appears more prone to this type of problem than others, the MA will impose a plus factor or take other appropriate supervisory responses to encourage the AI to improve the model's accuracy.

B5.4 The third category of problem, i.e. unanticipated market movements, is also expected to occur at least some of the time with an internal model. Even an accurate model cannot be expected to cover 100% of trading outcomes. Some exceptions will be in the random 1% that the model can be expected not to cover. In other cases, the behaviour of the markets may shift so that previous estimates of volatility and correlation are no longer appropriate. No VaR model will be immune from this type of problem; it is inherent in the reliance on past market behaviour as a means of gauging the risk of future market movements. Exceptions due to such reasons do not suggest a problem. If, however, the shifts in volatilities and correlations are considered to be permanent, the MA may require the AI to re-calculate its VaR measures using volatilities and correlations based on a shorter observation period.

B5.5 Depending on the definition of trading outcomes employed for back-testing purposes, exceptions could also be generated by intra-day trading results or an unusual event in trading income other than from the trading outcomes arising from an AI's portfolio. Although exceptions arising from these reasons may not necessarily suggest a problem with the internal model, they could still be causes for concern. The imposition of the plus factor will be considered by the MA in such circumstances.

B5.6 Another consideration is the extent to which a trading outcome exceeds the VaR measure. With all other things being equal, exceptions generated by trading

outcomes far in excess of the VaR measures are of greater concern than those outcomes which are only slightly larger than the VaR measures.

B5.7 In deciding an appropriate supervisory response to an AI, the MA will weigh the above factors, together with his assessment of the extent of the AI's compliance with the qualitative criteria set out in section 2 and any additional information provided by the AI in respect of the quality of its internal model. In general, the imposition of a plus factor on an AI for outcomes in the yellow zone will be considered an appropriate supervisory response if the MA believes the reason for being in the yellow zone is a problem in the internal model that can be corrected. This is contrasted with the case of an unexpected bout of high market volatility (i.e. temporary), which nearly all models may fail to predict.

Annex C: Stress-testing

C1. General

C1.1 An AI which uses the IMM approach for calculating its market risk capital charge should have a rigorous and comprehensive stress-testing programme. Stress-testing is to identify events or influences that could significantly impact the AI's financial soundness and forms a key component of the AI's internal assessment of capital adequacy. This Annex should be read in conjunction with IC-5 "Stress-testing" that provides general guidance on the use of stress tests for risk management purposes.

C1.2 An AI's stress scenarios need to cover a range of factors that can create extraordinary losses or gains in its trading portfolios or make the control of risk in those portfolios very difficult. These factors include low probability events in all major types of risk, including the various components of market, credit, liquidity and operational risks. Stress scenarios need to shed light on the impact of such events on positions that display both linear and non-linear price characteristics (i.e. option positions and any other positions that have option-like characteristics).

C1.3 An AI's stress tests should be of a quantitative and qualitative nature. Quantitative criteria should identify plausible stress scenarios to which the AI could be exposed. Qualitative criteria should emphasise that two major goals of stress-testing are to evaluate the capacity of the AI's capital to absorb potential large losses and to identify steps the AI can take to reduce its risk and conserve capital.

C1.4 An AI's stress tests should also incorporate both market risk and liquidity aspects of market disturbances. For example, an AI may not be able to unwind some trading positions quickly during a crisis situation and the values of these positions may be very volatile. Such

considerations are particularly important for positions in emerging markets.

C1.5 An AI should combine the use of supervisory stress scenarios with its own stress tests to reflect its specific risk characteristics. In particular, the MA may require the AI to provide information relating to its stress-testing results in three broad areas as discussed in sections C2 to C4.

C2. Supervisory scenarios requiring no simulation by the AI

C2.1 An AI should provide the MA with information on its five largest daily losses experienced during each calendar quarter. Such losses should be reported in Part IV of the "Return of Capital Adequacy Ratio of an Authorized Institution Incorporated In Hong Kong - MA(BS)3(IV)".

C2.2 This loss information can be compared to the level of an AI's capital and the corresponding VaR measures that are generated from the AI's internal models. This comparison will help provide the MA with a picture of how many days of peak daily losses incurred by the AI would have been covered by its corresponding VaR measures.

C3. Supervisory scenarios requiring simulation by the AI

C3.1 An AI should subject its portfolios to a series of simulated stress scenarios and provide the MA with the results at least quarterly. These scenarios may include testing the AI's current portfolio against past periods of significant disturbance, for example, the 1987 equity crash, the 1992/1993 Exchange Rate Mechanism crises, the fall in bond markets in the first quarter of 1994, the Mexican crisis at the end of 1994, the 1997/1998 Asian Financial Crisis, the 1998 Russian financial crisis, the 2000 bursting of the technology stock bubble, or the 2008/2009 Global Financial Crisis, incorporating both the large price movements and the sharp reduction in liquidity associated with these events.

C3.2 A second type of scenario is to evaluate the sensitivity of an AI's market risk exposures to changes in the assumptions about volatilities and correlations. Applying this test requires an evaluation of the historical range of variation for volatilities and correlations and evaluation of the AI's current positions against the extreme values of the historical range. Due consideration should be given to the sharp variation that at times has occurred in a matter of days in periods of significant market disturbance. For example, in some instances the crises mentioned in subsection C3.1 involved correlations within risk factors approaching the extreme values of 1 or -1 for several days at the height of the disturbance, and some assumptions on correlations among risk factors no longer held true under stressed market conditions.

C4. Scenarios developed by the AI

C4.1 An AI should also develop its own stress tests which it identifies as severe but plausible events based on the characteristics of its portfolio (e.g. problems in a key region of the world combined with a sharp move in oil prices). The AI should provide the MA with a description of the methodology used to determine the scenarios as well as a summary of the results derived from these scenarios.

C5. Stress-testing for incremental risk charge and comprehensive risk charge

C5.1 Where an AI models a comprehensive risk charge for exposures in a correlation trading portfolio, the AI should regularly conduct stress-testing for those exposures in accordance with the specific guidance set out in sections E2 to E5 of Annex E.

C5.2 Where applicable, an AI should also regularly conduct stress tests on its internal approach to calculating incremental risk charge. For this purpose, see guidance on stress tests for comprehensive risk charge that relates to the default and credit migration risks of

market risk exposures subject to incremental risk charge.

C6. An AI's internal capital adequacy assessment

C6.1 An AI's assessment of the adequacy of internal capital for market risk, at a minimum, should be based on its estimates of VaR, stressed VaR and other market risk capital charges applicable to the AI, and stress-testing appropriate to its trading activity, including an assessment of concentration risk and of illiquidity under stressed market conditions.

C6.2 An AI should supplement its VaR models with stress tests (i.e. factor shocks or integrated scenarios whether historical or hypothetical) and other appropriate risk management techniques. In its internal capital adequacy assessment, the AI should demonstrate that it has enough capital to not only meet the minimum regulatory capital requirements but also to withstand a range of severe but plausible market shocks. In particular, it should factor in, where appropriate -

- illiquidity / gapping of prices;
- concentrated positions (in relation to market turnover);
- one-way markets[21];
- non-linear products / deep out-of-the-money positions;
- event risk and jump-to-default risk;
- significant shifts in correlations; and
- other risks that may not be captured appropriately or adequately in VaR, stressed VaR, incremental risk charge or comprehensive risk charge (e.g.

[21] "One-way market" refers to a market in which only the offer or bid price of an instrument exists (i.e. an illiquid market).

recovery rate uncertainty, implied correlations or skew risk).

C6.3 The stress tests applied by an AI and, in particular, the calibration of those tests (e.g. the parameters of the shocks or types of events considered) should be reconciled back to a clear statement setting out the premise upon which the AI's internal capital adequacy assessment is based (e.g. ensuring there is adequate capital to manage the trading book portfolios within stated limits through what may be a prolonged period of market stress and illiquidity, or that there is adequate capital to ensure that, over a given time horizon to a specified confidence interval, all positions can be liquidated or the risk hedged in an orderly fashion). The market shocks applied in the tests should reflect the nature of the AI's portfolios and the time the AI could take to hedge out or manage risks under severe market conditions.

C6.4 An AI should demonstrate how it combines both VaR and stressed VaR measures, and (where applicable) incremental risk charge and/or comprehensive risk charge, generated from its internal models and the results of its stress tests to arrive at the overall internal capital for market risk.

C6.5 If the MA considers that an AI does not have sufficient internal capital taking into account the results of the AI's stress tests, the MA may require the AI to reduce its market risk exposures or hold additional capital through the supervisory review process (see CA-G-5 "Supervisory Review Process").

Annex D: Calculation of incremental risk charge

D1. General

D1.1 This Annex applies to AIs which use, or intend to use, the IMM approach to model specific risk for exposures that are subject to incremental risk charge.

D1.2 The purpose of modelling an incremental risk charge is to capture and adequately reflect, on a continuing basis, the default risk and credit mitigation risk inherent in an AI's relevant trading book positions that are not already captured in its VaR calculations (i.e. incremental risks).

D1.3 An AI should have an internally developed approach to calculate incremental risk charge for its non-securitization specific risk interest rate exposures falling within paragraph (a) of the definition of "incremental risk charge" (see section 1.1.2). The relevant model for generating this charge should not capture any positions in securitization exposures or n^{th}-to-default credit derivative contracts, even when such positions are viewed as hedging the underlying exposures held in the trading book.

D1.4 An AI may, at its discretion, seek to include all listed equities and equity-related derivative contracts based on listed equities in the calculation of incremental risk charge provided that –

- the inclusion of such exposures in the calculation is consistent with how the AI internally measures and manages the default risk and credit mitigation risk of such exposures;
- such exposures are included in the incremental risk charge calculation in a consistent manner; and
- the AI applies §149 of the Rules in determining whether a default in such exposures has occurred.

D1.5 The MA recognises that there is no single industry standard for the calculation of incremental risk charge. As such, no specific approach for its calculation is prescribed. However, an AI must have the prior approval of the MA under §18(2) of the Rules to use an internally developed approach to model incremental risk charge for relevant exposures held in its trading book.

D2. Key supervisory parameters for calculating incremental risk charge

Soundness standard comparable to IRB approach

D2.1 An AI should demonstrate that its model for calculating incremental risk charge ("IRC model") meets a soundness standard comparable to that for the internal ratings-based approach ("IRB approach") for credit risk under the Rules, using the assumption of a constant level of risk and with any necessary adjustments to reflect the impact of liquidity, concentrations and hedging on, and the option characteristics of, the AI's market risk exposures.

Constant level of risk over one-year capital horizon

D2.2 The IRC model should adopt, consistently and across all of the positions subject to this charge, the assumption of a constant level of risk over a one-year capital horizon[22].

[22] This assumption is consistent with the capital calculations in the Basel II capital framework. In all cases (loans, derivatives and repos), the Basel II framework defines exposures at default in a way that reflects a roll-over of existing exposures when they mature. The combination of a constant level of risk assumption and a one-year capital horizon reflects supervisors' assessment of the appropriate level of capital needed to support the risk in the trading portfolio. It also reflects the importance to the financial markets of AIs having the capital capacity to continue providing liquidity to the financial markets in spite of trading losses. Consistent with a "going concern" view of an AI, this assumption is appropriate because an AI must continue to take risk to support its income-producing activities. For regulatory capital purposes, it is not appropriate to assume that an AI would reduce its VaR to zero at a short-term horizon in reaction to large trading losses. It also is not appropriate to rely on the prospect that an AI could raise additional Tier 1 capital during stressed market conditions.

D2.3 The assumption of a constant level of risk implies that an AI rebalances, or rolls over, its trading book positions over a one-year capital horizon in a manner that maintains the initial level of risk, as indicated by a metric such as VaR or a profile of exposures by credit rating and concentration. This means incorporating the effect of replacing, at the end of a liquidity horizon, positions that have experienced default or credit migration over that liquidity horizon with positions that have risk characteristics equivalent to those of the original positions held by the AI at the start of the liquidity horizon. The frequency of the assumed rebalancing should be governed by the liquidity horizon for a given position.

D2.4 However, rebalancing positions does not imply that the same positions will be maintained throughout the capital horizon, as the IRB approach for the banking book does. An AI may elect to use a "one-year constant position" assumption, as long as the AI consistently applies this standard across all of its positions subject to incremental risk charge.

Liquidity horizon

D2.5 Stressed credit market events have shown that markets do not always remain liquid. Banks may experience significant illiquidity in a wide range of credit products held in their trading book, including leveraged loans, or across different asset markets, for prolonged periods of time under stressed conditions. An AI is therefore expected to make appropriate assumptions for the liquidity horizon within its IRC model. The factors for determining the liquidity horizon include, but are not limited to, the following:

- the liquidity horizon should be measured under conservative assumptions and should be sufficiently long such that the act of selling or hedging, in itself, does not materially affect market prices;

- the AI may take into account internal policies relating to, for example, prudent valuation and valuation adjustments[9], and the management of stale positions;

- in general, within a given product type, a non-investment-grade position is expected to have a longer assumed liquidity horizon than an investment-grade position. Thus conservative assumptions regarding the liquidity horizon for non-investment-grade positions are warranted until further evidence is gained regarding market liquidity during systemic and idiosyncratic stressed situations;

- irrespective of the rating of the positions or set of positions, conservative liquidity assumptions should be applied for products where -

  (a) secondary market liquidity is not deep, particularly during periods of financial market volatility and investor risk aversion; and

  (b) the product class is experiencing rapid growth and has not been tested in a downturn;

- the liquidity horizon for positions that are concentrated is expected to be long, reflecting the longer period needed to liquidate such positions and the need to provide adequate capital against market concentration; and

- the AI has the option of assessing liquidity by position or on an aggregate basis (i.e. by "buckets"). If an aggregate basis is used, the aggregation criteria should be defined in a way that meaningfully reflects differences in liquidity.

Correlations and diversification

D2.6 Economic and financial dependence among obligors causes a clustering of default and credit migration events. Accordingly, an AI's IRC model should take into account the impact of such clustering of events. The AI should also ensure that any issuer concentration identified in its portfolios would be reflected in the correlation assumptions of the model, and provide adequate capital against it.

D2.7 The impact of diversification between default or credit migration risks in the trading book and other risks in the trading book is not currently well understood. Therefore, for the time being, the impact of diversification between default or credit migration events and other market variables will not be reflected in the incremental risk charge [23]. Accordingly, the incremental risk charge is added to the VaR-based market risk capital charge.

Concentration

D2.8 Issuer and market concentrations should be appropriately reflected in an AI's IRC model. Thus, other things being equal, a concentrated portfolio should attract a higher capital charge than a more granular portfolio. Concentrations that can arise within and across product classes under stressed conditions should also be included.

Risk mitigation and diversification effects

D2.9 The netting of exposure amounts within an AI's IRC model is only permitted when the long and short positions refer to the same financial instrument. Otherwise, exposure amounts should be captured on a gross (i.e. non-netted) basis. Thus, hedging or diversification effects associated with long and short positions involving different instruments or different

[23] This is consistent with the Basel II capital framework, which does not allow for the benefit of diversification when combining capital requirements for credit risk and market risk.

securities of the same obligor (i.e. "intra-obligor hedges"), as well as long and short positions in different issuers (i.e. "inter-obligor hedges"), may not be recognised through netting of exposure amounts. Rather, such effects may only be recognised by capturing and modelling separately the gross long and short positions in the different instruments or securities.

D2.10 The IRC model should incorporate any basis risks. For example, the model should reflect the following:

- where there are significant basis risks by product, seniority in the capital structure, internal or external rating, maturity, vintage for offsetting positions as well as differences between offsetting instruments, such as different payout triggers and procedures; and

- where material, the impact of potential risks that could occur during the interval between the maturity of an instrument and the liquidity horizon in the case that the instrument has a shorter maturity than the liquidity horizon, or a maturity which is longer (but not contractually assured) than the liquidity horizon.

D2.11 An AI may recognise a rebalancing of the hedge within the liquidity horizon of the hedged position for trading book positions that are typically hedged via dynamic hedging strategies. Such recognition is only admissible if the AI –

- chooses to model rebalancing of the hedge consistently over the relevant set of trading book risk positions;

- demonstrates that the inclusion of rebalancing results in a better risk measurement; and

- demonstrates that the markets for the instruments serving as the hedge are liquid enough to allow for this kind of rebalancing even during periods of stress.

Any residual risks resulting from dynamic hedging strategies should be reflected in the capital charge. An AI should validate its approach to capture such residual risks to the satisfaction of the MA.

Optionality

D2.12 An AI's IRC model should reflect the impact of optionality. Accordingly, the IRC model should include the non-linear impact of option contracts and other positions with material non-linear behaviour with respect to price changes. The AI should also have due regard to the amount of model risk inherent in the valuation and estimation of price risks associated with such products.

D3. Validation

D3.1 An AI should apply the validation principles described in this module and CA-G-4 "Validating Risk Rating Systems under the IRB Approaches", as appropriate, in designing, testing and maintaining its IRC model. This includes evaluating conceptual soundness, ongoing monitoring that covers process verification and benchmarking, and outcomes analysis.

D3.2 Factors that should be considered in the validation process include the following:

- liquidity horizons should reflect actual practice and experience during periods of both systemic and idiosyncratic stresses;
- the IRC model for measuring incremental risks over the liquidity horizon should take into account objective data over the relevant horizon and include comparison of risk estimates for a rebalanced portfolio with that of a portfolio with fixed positions;
- correlation assumptions should be supported by an analysis of objective data in a conceptually sound framework. If an AI uses a multi-period model to compute incremental risks, it should

evaluate the implied annual correlations to ensure they are reasonable and in line with observed annual correlations. An AI should validate that its modelling approach for correlations is appropriate for its portfolio, including the choice and weights of its systemic risk factors. An AI should document its modelling approach so that its correlation and other modelling assumptions are transparent to the MA;

- owing to the high confidence standard and long capital horizon of the incremental risk charge, robust direct validation of the IRC model through standard back-testing methods at the 99.9% and one-year soundness standard will not be possible. Accordingly, the validation of an IRC model necessarily should rely more heavily on indirect methods including but not limited to stress tests, and sensitivity and scenario analyses, to assess its qualitative and quantitative reasonableness, particularly with regard to the model's treatment of concentrations. Given the nature of the soundness standard for the incremental risk charge, such tests should not be limited to the range of events experienced historically. The validation procedures adopted by an AI for its IRC model should be subject to the satisfaction of the MA; and

- an AI should strive to develop relevant internal modelling benchmarks to assess the overall accuracy of its IRC model.

D4. Use of internal models to calculate incremental risk charge

D4.1 Due to the lack of established and proven industry standards, it is anticipated that AIs will develop different approaches for modelling incremental risk charge. However, the approach that an AI uses to measure the incremental risk charge is subject to the "use test". Specifically, the AI should demonstrate to the satisfaction of the MA that its internally developed approach to measure incremental risk charge is

consistent with the AI's internal risk management methodologies for identifying, measuring and managing trading risks .

D4.2 Ideally the principles set out in this module should be incorporated into an AI's internal models for measuring trading book risks and assigning an internal capital charge to these risks. However, in practice an AI's internal approach for measuring trading book risks may not map directly to these principles. In such instances, the AI should demonstrate that the application of the internal approach to calculating incremental risk charge would deliver a charge at least as high as the charge produced by a model that directly applies the principles set out in this module.

Annex E: Calculation of comprehensive risk charge

E1. General

E1.1 This Annex applies to AIs which use, or intend to use, the IMM approach to model specific risk for exposures within a correlation trading portfolio.

E1.2 Subject to the prior approval of the MA, an AI may calculate a comprehensive risk charge for its correlation trading portfolio using an internally developed approach. The purpose of modelling this capital charge is to capture and adequately reflect, on a continuous basis, not only the incremental risks but all material risk factors affecting market risk inherent in an AI's correlation trading portfolio.

E1.3 The use of a model to calculate comprehensive risk charge ("CRC model") is only available to AIs which are active in buying and selling correlation trading products, having regard to market perception and their own judgement of the significance of such activities to themselves and to the markets in which they operate.

E1.4 AIs that model comprehensive risk charge (which covers incremental risk charge) should, in addition to complying with the specific requirements set out in this Annex, satisfy other requirements for incremental risk charge set out in Annex D that are applicable to comprehensive risk charge, with all necessary modifications[24].

[24] While AIs are allowed to enhance their IRC model to comply with the requirements for calculating comprehensive risk charge, they are not allowed to perform a single calculation covering exposures subject to incremental risk charge and exposures subject to comprehensive risk charge. Disallowing a single calculation has the effect of not allowing any diversification between the portfolios.

E2. Additional requirements for comprehensive risk charge

E2.1 An AI's CRC model should adequately capture the salient risks of exposures in its correlation trading portfolio, including –

- the cumulative risk arising from multiple defaults, including the ordering of defaults, in tranched products;
- the credit spread risk, including the gamma and cross-gamma effects;
- the volatility of implied correlations, including the cross-effect between spreads and correlations;
- the basis risk, including both the basis between the spread of an index and that of its constituent single names, and the basis between the implied correlation of an index and that of bespoke portfolios;
- the recovery rate volatility, as it relates to the propensity for recovery rates to affect tranche prices; and
- to the extent that the comprehensive risk charge incorporates benefits from dynamic hedging, the risk of hedge slippage and the potential costs of rebalancing such hedges.

E2.2 An AI should have sufficient market data to ensure that its CRC model fully captures the material risks of its correlation trading portfolio, and be able to demonstrate (for example, through back-testing) that the comprehensive risk charge generated from the model can appropriately explain the historical price variation of its correlation trading exposures.

E2.3 An AI should be able to segregate those positions which it has the MA's approval to incorporate into its calculation of comprehensive risk charge from those positions for which it does not have such an approval.

E2.4 An AI should regularly apply a set of specific, predetermined stress scenarios to its correlation trading portfolio, having regard to the guidance provided in sections E3 to E5[25] to examine the implications of stresses on —

- default rates;
- recovery rates;
- credit spreads; and
- correlations on the correlation trading portfolio's profit and loss.

E2.5 An AI should apply the above-mentioned stress scenarios at least weekly and report the results, including comparisons with the comprehensive risk charge calculated using the AI's internally-developed approach, to the MA within six weeks after the end of each quarter (or more frequently as may be advised by the MA).

E2.6 Whenever an AI's stress tests indicate a material shortfall in the comprehensive risk charge, the AI should report the same to the MA as soon as reasonably practicable in all the circumstances of the case. The MA would generally regard the submission of such exception reports within three business days from the day on which the material shortfall is identified in the AI's stress tests as a reasonable period. If the MA is satisfied that the stress-testing results do indicate a material shortfall in the comprehensive risk charge calculated by an AI, the MA may impose a supplemental capital charge on the AI, which is in addition to the comprehensive risk charge generated by its internal model.

[25] Such guidance follows that specified in the Annex to the document entitled "*Revisions to the Basel II market risk framework*" published by the Basel Committee in July 2009 and updated in February 2011.

E2.7 It is reasonable to expect that the size of any supplemental capital charge that may be imposed by the MA to address a material shortfall in the comprehensive risk charge of an AI would be broadly commensurate with the size of the shortfall. As the circumstances of individual AIs may vary, they should determine their own materiality threshold(s) for shortfalls in their comprehensive risk charge in a prudent and conservative manner. The factors that an AI may take into account for this purpose include, but are not limited to, the following —

- the nature, scale and complexity of the AI's correlation trading activities and the risks associated with those activities;
- the AI's risk appetite or tolerance, business strategy and risk limits applicable to its correlation trading activities;
- the robustness of the AI's market risk management systems and controls;
- the robustness of the AI's stress tests on its comprehensive risk charge;
- the AI's financial and capital adequacy positions; and
- the conditions in the external environment in which the AI is operating.

E2.8 The MA would normally assess the materiality of any shortfall in AIs' comprehensive risk charge on a case-by-case basis, having regard to the circumstances of individual AIs. In addition to any relevant factors mentioned above, the MA would take into account the following factors in determining whether, and how much, supplementary capital charge should be imposed on an AI in light of a material shortfall in its comprehensive risk charge —

- the methodology adopted by the AI in determining the materiality threshold for shortfalls in its comprehensive risk charge;

- the cause and size of the shortfall in the AI's comprehensive risk charge, the period of time for which the shortfall has lasted and the frequency at which such shortfalls have occurred;

- any remedial actions taken by the AI in response to the shortfall;

- the existence of any other prudential concerns in respect of the AI that may exacerbate the impact of the shortfall; and

- the level of systemic importance of the AI in the context of the Hong Kong banking sector.

E3. Stress-testing for correlation trading portfolio

E3.1 The goal of the stress-testing standards described in subsections E3 to E5 is to provide estimates of the mark-to-market ("MTM") changes that would be experienced by an AI's current correlation trading portfolio in the event of credit-related shocks. The standards encompass both prescribed regulatory stress scenarios and high-level principles governing an AI's internal stress-testing process.

E3.2 The prescribed scenarios are not intended to capture all potential sources of stress. Rather, their primary focus is on valuation changes involving large, broad-based movements in spreads for single-name bonds and credit default swaps, such as those accompanying systemic financial or macroeconomic shocks, and associated spillovers to prices for index and bespoke tranches and other complex correlation positions.

E3.3 In addition to the prescribed scenarios, an AI is expected to implement a rigorous internal stress-testing process to address other potential correlation trading

risks, including AI-specific risks related to its underlying business model and hedging strategies.

E4. Prescribed stress tests for correlation trading portfolio

E4.1 The prescribed stress scenarios set out in this subsection are framed in terms of risk factor movements affecting credit spreads over specific historical reference periods. The term "risk factor" encompasses any parameter or input within a pricing model that can vary over time. Examples include, but are not limited to, single-name risk-neutral default rates/intensities; recovery rates; market-implied correlations for index tranches; parameters used to infer market-implied correlations for bespoke tranches from those for index tranches; index-single name basis risks; and index-tranche basis risks.

Historical reference periods

E4.2 Historical reference periods, for the purposes of the prescribed stress tests, correspond to historical intervals of three months or less over which spreads for single-name and tranched credit products have exhibited very large, broad-based increases or decreases. For each stress test, the historical reference period is used to calibrate the size of assumed shocks to credit-related risk factors. This approach to calibrating the size of shocks is intended to accommodate the wide range of pricing models observed in practice.

E4.3 The specified historical reference periods are as follows:

- Periods of sharply rising credit spreads:

  (a) 4 June 2007 through 30 July 2007;

  (b) 10 December 2007 through 10 March 2008; and

(c) 8 September 2008 through 5 December 2008;

- Periods of sharply falling credit spreads:

  (a) 14 March 2008 through 13 June 2008; and

  (b) 12 March 2009 through 11 June 2009.

E4.4 In the future, the MA may modify the above historical reference periods, as the MA deems appropriate in the light of developments in correlation trading markets. In addition, the MA may require AIs to perform stress tests based on additional reference periods, or require additional stress tests based on methodologies different from those described in this module.

Historical stress tests

E4.5 For each historical reference period, several stress tests are to be undertaken. Each stress scenario involves replicating historical movements in all credit-related risk factors over the reference period. In these stress scenarios, only credit-related risk factors are shocked. For example, non-credit-related risk factors driving default-free term structures of interest rates and foreign exchange rates should be fixed at current levels.

E4.6 It is presumed that an AI's pricing model can be used to decompose historical movements in credit spreads into changes in risk factors. If the pricing model does not take this form explicitly, the AI will need to translate the stress scenarios into equivalent risk factor representations that are compatible with the structure of its pricing model. As with all aspects of the stress-testing standards set out in this Annex, such translations should be made in consultation with the MA and are subject to supervisory approval.

Jumps to default

E4.7 The preceding stress scenarios encompass changes in credit spreads, but defaults of individual firms are left out. The final set of stress tests incorporates assumptions of actual defaults into sector shock scenarios. For each of the historical scenarios referred to in subsection E4.5, an AI should perform four jump-to-default ("JTD") stress tests based on its current correlation trading portfolio:

- firstly, the AI should assume an instantaneous JTD with zero recovery of the corporate name in the portfolio having the largest JTD01[26] measure;
- secondly, the AI should assume JTDs with zero recovery of the two corporate names in the portfolio having the largest JTD01 measures; and
- similarly, in the third (fourth) stress test, the AI should assume JTDs with zero recovery of the three (four) corporate names in the portfolio having the largest JTD01 measures.

Additional technical guidance

E4.8 In the paras. below, a given historical reference period is identified by its start date (t) and end date (t+M).

E4.9 When calculating movements in risk factors over the historical reference period, the values of risk factors on dates t and t+M should be calibrated to be consistent with an AI's current pricing model and with actual market prices on those days.

E4.10 In carrying out the stress tests, the AI's methodology should reflect the current credit quality of specific names, rather than the name's credit quality during the

[26] JTD01 is defined as the estimated decline in the MTM value of the correlation trading portfolio associated with a JTD of that entity, assuming a zero recovery rate for the entity's liabilities.

historical reference period. For example, if the current credit quality of a particular firm is worse than that during the historical reference period, the shocks to risk factors for that firm should be consistent with those for similar quality firms over the reference period. Subject to the MA's approval, proxies for credit quality may be based on external ratings, implied ratings from credit spreads, or possibly other methods.

E4.11 The stressed MTM loss of an AI's current correlation trading portfolio should be calculated as the difference between its current MTM value and its stressed MTM value.

E4.12 MTM values should be based on full portfolio revaluation (e.g. with no delta approximations).

E4.13 Stress tests should be performed under the following assumptions:

- portfolio positions are held static at their current levels (e.g. no recognition of dynamic hedging within the period);
- all credit-related risk factors are instantaneously shocked;
- risk factors not directly related to credit risk (e.g., foreign exchange rates, commodity prices, risk-free term structures of interest rates, etc.) are fixed at current levels; and
- in general, within the prescribed stress tests, the difference between the shocked value and the current value of each risk factor should be set equal to its absolute (as opposed to relative) change between dates t and t+M. Exceptions are to be approved by the MA.

This treatment presumes that each stress scenario generates price effects that are internally consistent (e.g. positive spreads, no arbitrage opportunities, etc.). If this is not the case, a simple rescaling of certain risk

factors may address the issue (e.g. the relevant parameters should be revised to ensure that implied correlations and risk-neutral default rates and recoveries remain bounded between zero and one).

E4.14 In cases where the historical value of a risk factor at date t or t+M is not known (perhaps because the current pricing model differs from that used over the interval t to t+M), the risk factor value will need to be "back-filled". Subject to the MA's approval, the back-filling method used by an AI should be consistent with the current pricing model and observed historical prices at t and t+M.

E5. Internal stress-testing for correlation trading portfolio

E5.1 In addition to the above-mentioned prescribed stress tests, AIs that model comprehensive risk charge are expected to implement a rigorous internal stress-testing process for their correlation trading portfolios.

E5.2 Subject to supervisory review, an AI's internal stress-testing for its correlation trading portfolio should identify stress scenarios and then assess the effects of the scenarios on the MTM value of the portfolio. The framework should be flexible. Scenarios may be historical, hypothetical, or model-based, and may be deterministic or stochastic. Key variables specified in a scenario may include, for example, default rates, recovery rates, credit spreads, and correlations, or the scenarios may focus directly on price changes for positions in the portfolio. An AI may choose to apply scenarios to the entire portfolio, or the AI may identify scenarios specific to sub-portfolios of the portfolio.

E5.3 The internal stress tests should be economically meaningful, taking into account the current composition of an AI's correlation trading portfolio, the AI's business model for this desk, and the nature of its hedging activities. The form and severity of the stress scenarios should be developed with an eye toward their applicability to the unique characteristics (and vulnerabilities) of the current portfolio including, but not

limited to, concentration risks associated with particular geographic regions, economic sectors, and individual corporate names.

E5.4 Taking into account the specific nature of an AI's correlation trading portfolio, the internal stress tests should not be limited to the historical reference periods used for the prescribed stress tests described in section E4. The AI should also consider relevant historical experience over other time intervals, including periods within, around, or subsequent to, the historical reference periods specified above.