

**RECOGNISING A FIRM'S INTERNAL MARKET RISK MODEL
FOR THE PURPOSES OF CALCULATING REQUIRED
REGULATORY CAPITAL: GUIDANCE TO SUPERVISORS**



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SUMMARY

The purpose of this paper is to provide guidance to those supervisors which have decided in principle that VaR models for market risk have a part to play in their regulatory framework. It seeks to give supervisors practical guidance on how to assess their own expertise in this field and what the implications for the supervisory process are, as well as information that a supervisor should seek from a firm wishing to use VaR. It should be read in conjunction with the IOSCO Technical Committee's May 1998 report *'Methodologies for determining capital standards for internationally active securities firms which permit the use of models under prescribed conditions'*. The principles regarding the use of VaR models for the assessment of market risk, which were established in that paper, remain applicable.

The report: *'Methodologies for determining capital standards for internationally active securities firms which permit the use of models under prescribed conditions'* concluded that "VaR models can have a role in setting regulatory capital for market risks", but that "VaR models are more readily applicable in environments which have certain characteristics." Supervisors should not regard VaR models as being appropriate for all firms, or for all markets: supervisors which decide in principle that they wish to permit the use of models will therefore need to form a judgement on the merits of a particular firm's model and the firm's use of it, on a case by case basis.

The May 1998 report discussed in some detail how VaR models could be fitted into a regulatory capital framework - it pointed out that VaR methodologies have limitations and that "the market risk capital charge should be increased over and above the VaR output to address these limitations." For other non-modelled risks such as operational and legal risks, "additional capital or 'buffers' should be introduced over and above the market risk capital charge." The report concluded that "a combination of the new market risk capital charge, the existing charge for credit risk and additional buffers can provide sufficient capital. However, there is no implication in this report that the adoption of VaR models will lead to a fall in the current level of regulatory capital, but will instead enable firms to manage risks more efficiently".

Supervisors need to ensure that they have the resources and expertise to make appropriate supervisory judgements about the quantitative and qualitative aspects of a VaR approach. The adoption of VaR models involves a shift to greater reliance on a firm's internal controls and therefore requires an enhancement of the supervisor's ability to assess their effectiveness. IOSCO's 1998 report: *'Risk Management and Control Guidance for Securities Firms and their Supervisors'* established twelve benchmarks by which supervisors and securities firms can assess the adequacy of control systems. This paper gives some guidance on how these might be examined in a models environment.

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SECTION I

IOSCO Framework for Supervisors Assessing Market Risk Models to be Used for Regulatory Capital Purposes

Introduction

The IOSCO Technical Committee's May 1998 report: *'Methodologies for determining capital standards for internationally active securities firms which permit the use of models under prescribed conditions'* developed a framework to approach the use of models for regulatory capital purposes: the recognition of models requires involvement in the following areas:-

Eight Point Framework for the Assessment of Firms Using Market Risk Models

Verifying that VaR models are fully integrated into the day to day risk management processes of the firm with an appropriate level of independent verification

The IOSCO Technical Committee's May 1998 report on the use of VaR techniques to determine market risk charges agreed that a firm's capital charges should be based on the risks of its business (in so far as they can be measured), not least in order to give firms the right incentives to reduce risk. To the extent that VaR models assist in the achievement of these aims, it may be appropriate for supervisors to consider the circumstances in which use can prudently be made of them in assessing regulatory capital.

There are several reasons for seeking to ensure that differences between a firm's regulatory model and its internal risk management model are minimised:

- one of the best assurances of a model's quality is that the firm uses it as an integral part of its own risk management process;
- basing regulatory capital requirements on a firm's internal model helps preserve the incentives for a firm to measure its market risk as accurately and comprehensively as possible, and to continue to upgrade its model as markets and technology develop. In general, a firm is best placed to devise and operate its own internal model;
- In addition, this assists the regulator in focussing on the management's own assessment of the risks of the business, and how it is controlling them.

It should be acknowledged that a model which is devised solely for the purpose of calculating regulatory capital is less likely to maintain the incentive link to how the firm itself perceives its risk, measures it and manages it, and is more likely to be the result of the firm seeking to reduce its overall capital requirement.

However, requiring a perfect match between the firm's internal model and that used for calculating regulatory capital is unlikely to be desirable or practical. The aims of an internal model and the regulatory model may differ: the internal model will be primarily aimed at use

in day to day risk management; regulators give additional consideration to extreme and rare events (and for this and other reasons, may also require add-ons to model output).

Example: a firm may (particularly at trader level) take a rather different view of what holding period should be assumed than the regulator. Generally the holding period may be regarded as the assumed ‘worst case situation’ during which time no re-positioning or re-hedging of a portfolio may be undertaken. In practice it is likely that an institution would attempt to take action to prevent losses accruing, but their ability to do so will depend upon the markets being open, market makers being willing to deal, and the firm itself not being prohibited (because it is in administration, for example). A trader of liquid instruments may view information on a one-trading-day time horizon – assuming that he could liquidate his portfolio within this time-frame. The firm’s risk manager may supplement such information with a less optimistic view that in times of stress it can be difficult to trade, and risk may be evaluated on a holding period of a few weeks or months. Regulators are also likely to be more preoccupied by potential risk under stressed market conditions and to adopt a longer holding period.

Notwithstanding these differences regulators may wish to require areas of commonality between internal models and those used for calculating regulatory capital, for example:

- basic methodology (eg historic simulation)
- technology platform (ie it should be run off the same systems)
- data feeds relating to positions, prices, yield curves etc

Approving the parameters of the models, such as the minimum holding period, confidence level, and historical observation period.

Models will not always explain or forecast real market behaviour accurately. A supervisor should consider whether to permit each firm to use its model for regulatory purposes on a case by case basis: the supervisor should withhold permission where it is not satisfied that the model is suitably robust and that it adequately captures the material risks to which the firm is exposed. Model recognition is a judgement on the part of the supervisor that the firm’s model (quantitative standards) and the internal controls surrounding the firm’s model (qualitative standards) jointly meet a set of minimum requirements, in the context of that firm’s business activities at a particular point in time.

Before considering the appropriateness of the firm’s model for regulatory reporting, a supervisor will need to establish what the quantitative standards in respect of the model are to be (for example holding period, confidence level and historical observation period). These should be communicated clearly to the firm, either via a general policy communiqué, or at the stage when the firm applies for model recognition.

The following additional points need to be clearly understood by the firm:

- regulators will wish to review regulatory requirements over time in the light of experience with models;
- firms already operating under existing model recognition regimes (such as CAD2 and the Basle Market Risk Amendment) will need to observe the standards set out in these regimes. However, there is no presumption that the standards set by regulators in these or in other jurisdictions will not be more onerous. In addition, supervisors should note that

IOSCO is not by means of this paper seeking to endorse the particular standards laid down in Basle and CAD2 – supervisors should consider themselves what standards are appropriate in the context of their regulated firms and the markets in which they are involved;

- regulators may, in some circumstances, be willing to enter into a dialogue with a firm about the detailed means by which it satisfies the required quantitative standards – however, this will be on the basis that it does not compromise the level of capital required in respect of its market risk.

Assessing the reliability of the models including the use of correlations (eg through establishing a framework for backtesting)

Ensuring that firms regularly review the performance of their model and take action on the outcomes of their internal backtesting

Ensuring that firms supplement their modelling approach by a programme of stress testing that is appropriate to their particular risk profile and concentration of exposures

Obtaining appropriate and timely information on the outcomes of backtesting and stress testing

As noted in point 1 above, models used for the purposes of regulatory reporting should be integrated into the day to day risk management processes of the firm. Building a risk aggregation model is only one step on the path to sound risk management. IOSCO's paper 'Risk management and control guidance for securities firms and their supervisors' establishes that "a firm's governing body (board of directors, or equivalent)...should approve overall business strategies and risk management and control policies". It needs to be demonstrated to supervisors, therefore, that the development of a VaR model and its use in the risk management of the firm has been approved and its use is continually monitored at the very highest level in the firm; furthermore, that there is an adequate degree of understanding of the strengths and weaknesses of VaR techniques. Before granting recognition, and on an ongoing basis, supervisors should feel comfortable that a firm does not place undue reliance on its model, however sophisticated. It is essential that those responsible for managing the market risk at a firm should be aware of the assumptions and limitations of the firm's internal model, and that they should seek to understand, to question and to challenge the output of the model.

While VaR is a useful tool for measuring and managing risks, no single risk measure should be regarded as providing an adequate framework for risk management. As well as VaR measures, therefore, those responsible for risk management at the firm should regularly receive other forms of risk management information, including:

- backtesting results
- stress testing results

- sensitivity analysis
- information on positions and limits (including information on option products, and non-linear deviations)
- profit and loss information

Backtesting

In considering whether recognition is appropriate, a supervisor should ensure that the firm regularly tests the performance of its model. One way for the supervisor and/or the firm to assess model performance is to test whether the distribution of observed changes in the value of the firm's portfolio mirrors the distribution of value changes calculated by the model (ie. model predictions are compared to observed results as reflected in the firm's profit and loss account). Some refer to this as backtesting (it may also be known as reality testing).

Backtesting can help test the ongoing validity of assumptions built into the VaR model, for example an assumption of normal distribution. But it does not guard against all forms of model risk.

Example: where an option position is marked to model and both the VaR prediction and the firm's estimation of P&L are based on that input, backtesting will not detect any potential error.

Regardless of which particular backtesting variant a supervisor may choose as key for its own assessment purposes, firms should be expected to conduct a variety of tests of model performance. Supervisors should request documentary evidence of several diagnostic tests.

Further guidance on backtesting may be found in Appendix 1.

Stress Testing

As acknowledged above, a model makes a prediction based on a given set of input data at a particular point in time and making simplifying behavioural assumptions. A supervisor should therefore require as a condition of model recognition that a firm have in place a rigorous and comprehensive programme of stress testing.

In this context, stress testing is the identification and quantification of exposure to extreme but plausible moves in pricing parameters. It may take the form of changing distributional assumptions, for example from a normal to a skewed or fat-tailed distribution. It will include scenarios where correlation assumptions regarding the relationships between pricing of different instruments may be subject to estimation error or may change over time.

Stress testing is a tool with which to evaluate the capacity of the firm's capital to absorb potentially large losses, whether or not a firm uses VaR for its regulatory capital calculation. But a firm which uses VaR should routinely examine the implications for its trading position of breakdowns in the assumptions underlying the model and therefore stress testing has an important role.

One aim of stress testing is to identify the potential circumstances which would cause the firm its greatest loss, and to quantify the impact of this on the firm. Clearly each firm may face a very large number of possible scenarios, and no firm could use all possible circumstances in conducting its stress tests. The challenge facing each firm is to define a subset of scenarios, in the light of knowledge about its business and positions (as well as key model assumptions), which it believes have the potential to give rise to its worst losses and to use those for its stress tests. Whilst the particular scenarios involved will vary according to a firm's particular portfolio, a supervisor may nevertheless be able to identify a common set of scenarios that should at a minimum be calculated by all firms, for example a replication of the market disturbances experienced in the latter part of 1998.

Further guidance on stress testing and the sorts of information which supervisors should seek from their firms in this regard may be found at Appendix 2.

Given the wide range of possible stress tests, some of which are more resource intensive than others, it is difficult to give general guidance on the specification of minimum standards for the frequency of stress testing. However, both supervisors and firms should recognise that stress testing is an essential component of a firm's risk management, and that firms' portfolios may change significantly on a daily basis. Where this is the case, the firm should be expected to have at least the capacity to run stress tests at short notice (daily). More complex stress tests may be conducted at longer intervals, or on an ad hoc basis. The identification of appropriate scenarios and the running of stress tests should be a proactive, anticipative process on the part of the firm.

Independence of Risk Management and Model Verification Functions, and Evidence of Use of Testing Results

As IOSCO established in its 1998 paper: *Risk Management and Control Guidance for Securities Firms and their Supervisors*, "in terms of risk management and capital protection, the most consequential controls involve the segregation of duties between the trading function and the internal control and risk management functions...". This principle is no less true for firms which are using internal models, and, as the adoption of VaR models involves a shift to greater reliance on a firm's controls in the supervisory process, supervisors should look to examine this rigorously, in the context of the model testing and risk management framework discussed above.

For example, stress testing, as a form of risk management, should be the responsibility of a function which is wholly independent of the front office. It is nevertheless important that the scenarios used in stress testing are credible: it may be appropriate for the risk management function to involve (but not rely on) the front office in the identification of scenarios.

Backtesting results (as these indicate the accuracy of the model generating VaR predictions used in risk management), stress testing results and other risk management information should be communicated routinely and on a timely basis to those responsible for determining and managing the risk profile of the firm, and those responsible for setting trading limits and the limit structure. The results of stress testing should be discussed by the key decision-making bodies of the firm (eg. the market risk committee). These bodies should consider whether they are comfortable with the results, and whether they are consistent with the risk appetite of the firm.

Supervisors should seek to see evidence of these processes at work, for example via reports and minutes of meetings. Supervisors should also expect to see evidence that business decisions (cutting or hedging of positions and increases in capital) have on occasion been triggered by the results of stress testing.

In addition to examining on a periodic basis the documentation which the firm uses for its own risk management purposes, the supervisor may wish to establish a regulatory reporting requirement, whereby the firm is obliged to report at intervals on the nature and results of stress tests undertaken. It may also wish to examine reports of the firm's internal audit function (which should have as part of its duties, responsibility for the verification of the operation of this aspect of the firm's risk management controls).

Supervisors should also seek to see evidence of backtesting results. The purpose of this is two fold. Firstly the supervisor should be seeking to understand what use the firm itself has made of the results: to recalibrate the model, or to refine the profit and loss attribution process. Secondly, the supervisor should consider what implications the results have for determining regulatory capital based on model output (ie. the accuracy of the model output used in the calculation).

As the IOSCO risk management paper establishes, an effective internal audit function is one of the key means by which a firm can verify that internal controls are operating in the manner prescribed by the firm's senior management. Supervisors should therefore establish that the firm has such a function, that its scope encompasses the use of the model, and the operation of surrounding controls.

Satisfying themselves that firms have adequate financial and human resources to adopt and operate a VaR model

VaR models cannot be regarded as a 'cheap option'. As is clear from the above, where a firm wishes to utilise a VaR model, it is necessary to have highly skilled personnel in the risk management, and indeed the internal audit functions of the firm. This is required if the necessary segregation of duties from the trading function is to be maintained, with available personnel having appropriate skills to use and maintain the model and to test the validity of its output.

Use of Off-the-Shelf Models

A firm may wish to develop its own internal model, or alternatively may seek to adapt an 'off-the-shelf' model for its own purposes. Smaller firms, especially, may regard the latter as an attractive option. Whilst an 'off-the-shelf' model may appear a simple solution, the work involved in adapting such a model and the necessary degree of expertise should not be underestimated. Clearly key in this exercise is ensuring that the model is appropriately integrated into the firm's existing systems and into its risk management process. In essence, while the purchase of a commercially available model may save on development costs, it is still necessary for the firm to have personnel with the requisite skills to understand the key assumptions made by the model, and its weaknesses, and to interpret its output within the context of the user firm. In addition the firm will require personnel with skills to adapt existing systems to provide the necessary data feeds, and who have sufficient understanding both of the nature of the firm's business and the model to determine appropriate parameters

for input data. Such personnel may be relatively scarce, and may command correspondingly high salaries.

Because a firm's business is not static, the model must be maintained on an ongoing basis. Risk factors which were originally considered to be immaterial in the context of the firm's overall business, may become more significant over time, in which case the firm will need to adapt its model to capture them better. In addition, the firm will need to consider any new products and how those are to be incorporated.

Therefore, as part of its initial assessment process, and indeed on an ongoing basis, the supervisor will need to assure itself that the firm has sufficient personnel of adequate calibre not just to operate the model but to exercise the key controls surrounding its use. In a changing business environment, a supervisor will need to consider how the firm's surrounding control infrastructure would identify and capture these changes to ensure that the model is maintained and remains appropriate in scope, and in nature, to the type of business which the firm is undertaking. Ordinarily, therefore, supervisors should be very cautious in approving the use of off-the-shelf models.

Determining an additional amount of capital to be added to the value at risk (VaR) number as a safeguard against unavoidable shortcomings of the VaR approach.

Where a firm requests that it may use its internal model for the purposes of determining its regulatory capital requirement, the supervisor should set clear and prudent standards relating to the conversion of the model output to the firm's total capital requirement.

This was explored in some detail in IOSCO's 1998 paper: '*Methodologies for determining capital standards for internationally active securities firms which permit the use of models under prescribed conditions*'. The paper recommended that two types of explicit buffers should be introduced into the capital calculation:

- A cushion against model risks (including inadequate capture of extreme market moves) – supervisors should be aware that models do not adequately address certain types of risk to which a firm may be exposed by virtue of holding positions, for example, models do not address event risk well and may not fully capture concentration risk in a firm's portfolio, or illiquidity of positions. It is for this reason that firms should supplement the use of VaR models with other risk management information, including stress-testing. Supervisors will wish to examine such information in deciding what additional capital requirements to set.
- Second, a cushion for operational risk and other non-modelled risks (other than credit risk which is assessed under the existing 'standard rules' approach and then aggregated with the model based market risk requirement).

Supervisors are recommended to refer back to IOSCO's 1998 publication for further guidance in this area.

The supervisor should give consideration to the types of products and markets in which the firm has positions, and should form a judgement as to whether a VaR model is an appropriate basis on which to determine capital requirements for these. Certain markets may pose

particular challenges: asset markets may be illiquid, data series may suffer gaps, or they may not be sufficiently long to use in a VaR model. The supervisor may therefore wish to define the scope of the model (having regard for the materiality of such positions within the firm's overall portfolio), such that the firm uses the model for certain of its positions, but assesses the capital requirements in respect of the remainder under a standard rules approach. The supervisory considerations in respect of such 'partial models' are discussed further in Section III of this paper.

SECTION II

Considerations for Supervisors

Introduction

Where a supervisor is considering recognising a firm's internal model for the purposes of calculating regulatory capital, it should give due thought to the consequences for its own supervisory process, and the implications for resourcing. It is likely that amendments to the supervisory process will be needed. Also it should review whether its personnel have the requisite skills to make the necessary quantitative judgements in respect of the model and qualitative judgements in relation to the model's operating environment at the firm.

Firms considering an application for model recognition should be encouraged to contact their supervisor at an early stage. Whilst, as referred to in Section I, each supervisor should set out in writing the standards which it requires, no regulator will be able (or should attempt) to set out in writing the total requirements for every model at any firm. Only by discussion with the regulator can a firm come to understand how the minimum standards are likely to be applied to it, and likewise, can the supervisor become informed to the necessary degree about the details of the firm's model and its operating environment. Experience has shown that such contact with the regulator can help the firm to prioritise its model recognition project, and that it can serve as a useful 'reality check' - the firm may realise that it has more to do to satisfy the regulator's requirements than it had previously believed.

Before permission to use the model is granted by the supervisor, the supervisor must be satisfied that its minimum standards are met. Factors to be considered particularly in a VaR context are set out in the first section of this guidance, and some guidance on information to be sought, and the means by which the firm's compliance with these standards might be tested, are set out in Appendix 3.

Assessment of Qualitative Standards

Regulators may wish to specify qualitative standards relating to the use of models by firms, for example in respect of the involvement of the Board of Directors or senior management, or in respect of stress testing requirements, but there are additional standards to which consideration should also be given by supervisors. In particular the completeness and quality of the inputs to the models, and the reliability of the systems on which the model is based, are crucial factors in determining the adequacy of the model output, and the use of that output in the firm's risk management process.

This shift to a greater reliance on the firm's internal systems and controls therefore requires an enhancement in the supervisor's ability to assess their effectiveness, as was noted in IOSCO's May 1998 report. Supervisors should therefore have particular regard for the recommendations in IOSCO's paper: *Risk Management and Control Guidance for Securities Firms and their Supervisors* - specifically that they should "promulgate regulations requiring the establishment of specified risk management and controls at regulated entities and require periodic reports and examinations of compliance with the regulations" across the range of the

firm's activities and not solely in relation to its market risk model. However, where a model is in use, this is likely to require a greater sophistication in the control environment of the firm.

The presentation to firms of how a supervisor exercises its judgement in this regard may be a challenge in itself. Supervisors may therefore wish to give consideration to what procedures and proforma documentation may be developed (for example, structured schedules of areas to be inspected, questionnaires, and policy databases). These have the dual benefit of ensuring that the recognition process is controlled and consistent between firms, and of assuring firms that the recognition process is systematically and fairly applied.

It is worth noting here, that the experience of supervisors whose firms are already starting to use internal models for the reporting of market risk requirements, is that the balance of regulatory effort tends to be in relation to how the firm satisfies the qualitative criteria. It is likely that testing the model will take up rather less supervisory time than the aggregate time to consider completeness and quality of model inputs, systems, controls and use of model outputs.

Resourcing Considerations

Both in the consideration of the firm's initial application for model recognition, and in ongoing supervision, it will be necessary for the supervisor to ensure that it has the means to test that the firm has met the required quantitative standards, for the model, and that the qualitative and controls requirements are satisfied. This clearly has implications for the resourcing of the supervisor:

- it will require sufficient numbers of staff with quantitative skills;
- examining the integration of the firm's model into its risk management process, testing key surrounding controls and examining the adequacy of systems and data feeds are likely also to require specialised skills and to be a resource intensive exercise.

Use of External Service Providers

Some supervisors may wish to consider whether they may 'subcontract' the examination and testing of some of these elements to external service providers, for example models or systems experts, or auditors. What remains of primary importance, however, is that while the supervisor may delegate some of the analysis and testing, it cannot delegate the requirement to exercise judgement. It must itself have the capability to form an opinion on the robustness of the model and its appropriateness to a firm's particular business. The supervisor must be sufficiently informed, and have within its personnel the skills, to judge for itself that:

- standards required of the model and its operating environment are met
- the firm has a clear and robust system of internal controls generally, as well as specific controls and information flows appropriate to the use of the model for risk management purposes

- that the firm's personnel, including senior management, those with responsibility for day to day risk management and those with responsibility for verifying that the firm's internal controls are operating as intended, have apposite skills and understand the regulatory requirements, too.

In practice, where supervisors make use of external service providers, they should assess the competence of those institutions to carry out the required work. They should also consider whether the required degree of reliance may be placed upon their reports, for example the extent to which disclaimers are incorporated in these. Lastly, the supervisor should ensure that the service provider is not 'conflicted', for example by having designed the systems on which it is asked to report. The monitoring of standards of external service providers by a supervisor is itself likely to be a skilled and potentially resource intensive activity.

Use of Specialist Teams

Some supervisors have established specialist teams with the responsibility for VaR model recognition. Given the evident economies of scope, these specialist teams are typically also responsible for the assessment of swap and option pre-processing models, and for wider assessments of the adequacy of firms' market risk management. The use of a specialist team should not undermine consistency of approach with the general supervision of firms, and therefore thought should be given to how such a specialist team interfaces with those responsible for the general supervision of firms on a day to day basis.

Managing the Application Process

It is up to firms to choose whether or not to apply for model recognition, and the timing of their applications. Model recognition is costly for firms to obtain: this helps restrict demand for supervisory recognition, but may also, where a firm has embarked on such a track, increase pressure from the firm on the supervisor to recognise its model, even where it falls short of required standards. However, having clear recognition criteria and processes, which are understood by firms, will help the regulator to withstand such pressures.

Model applications are unlikely to arrive at a constant rate, and may therefore raise logistical difficulties for supervisors in relation to human resources planning. Demand for recognition at any one time may exceed the supervisor's capacity to consider it: the supervisor may have to ration model recognition by introducing a queuing system, or, alternatively and perhaps more fairly, by conducting visits to different firms in parallel, and thus lengthening the process for all applicant firms.

It is likely to prove counter-prudential for supervisors to impose VaR implementation target dates on their firms. The development of a VaR model and the systems and controls surrounding it, to the standards required by supervisors, is a costly and lengthy task for a firm. The task is likely to require the use of scarce resources, and there may be an opportunity cost to the firm, if they are diverted from alternative projects. Therefore, a supervisor should not unduly distort the firm's resource allocation decisions: it is not clear that a firm's control environment would be improved under such compulsion, and it is better for a firm to learn to walk before it attempts to run. Of course, a firm may decide that VaR is not the way it wishes to manage its business, and may therefore not apply for model recognition at all. Those firms

which do wish to use a model may apply for recognition in a piecemeal fashion – see Section III ‘partial models’.

Ongoing Supervision

Once a firm has been permitted to commence using its model for regulatory reporting, a supervisor will need to ensure that the firm and its model continue to satisfy the minimum quantitative and qualitative standards. Examining the results of the firm’s backtesting and stress testing procedures are necessary parts of this, but are not sufficient in isolation.

Since firms are dynamic creatures and their businesses evolve over time, model recognition should not be granted in perpetuity:

- whilst all key factors should be tested by the supervisor as part of the model recognition process, factors should be periodically re-tested to ensure that the minimum standards continue to be met, or that identified areas in need of improvement are indeed being addressed by the firm;
- supervisors and firms should agree upon the procedures and reporting requirements applicable between visits: in respect of backtesting and stress testing etc; and in respect of material changes to the model, trading strategy or firm’s personnel.

This means that supervisory resources cannot be allocated to the model recognition process for a finite period only.

SECTION III

Specific Issues

Partial Models and Amending the Model to Capture New Products

Not every firm will be able to satisfy its regulator's minimum standards for VaR model recognition across its entire trading book at the time when it seeks recognition. Its VaR model may have a good track record for its equity risk, but less so for its interest rate risk; or for its sovereign and investment grade corporate bonds, but not for its high yield book; in one legal entity within a group, but not within another, etc. One regulatory approach would be to limit recognition solely to firms with fully developed, universal VaR models. However, this would be likely to disadvantage the more complex institutions; and it would dull the incentive for continuous improvement that piecemeal recognition can provide.

In practice, therefore, supervisors are likely to receive applications for VaR models which cover only a subset of the risks in a firm's trading book: 'partial models', or indeed a supervisor may decide to (initially) restrict the scope of a model to those products and markets which it feels the model covers well (and to require the firm to continue assessing capital for its other positions under a standard rules approach).

Whilst there is in principle no reason why a firm should not be permitted to use a partial model, this does raise the issue of risk aggregation for the purposes of calculating regulatory capital requirements. A supervisor may consider that a firm should not be permitted to use a model only for certain specified instruments in a broad risk factor but that it should satisfy the required standard for all positions it has in that risk factor – this may help to ensure that the firm captures risk concentrations and will help to avoid cherry picking.

Example: a supervisor may decide not to grant a firm permission to use its model for FTSE100 equities (only) when it also has positions in other equities.

Furthermore, firms that use an internal model for one broad risk factor, but not for others, should be expected over time, to strive to extend their models to calculate (nearly) all of their market risk requirements.

However, a firm may never succeed in capturing the totality of its market risks within its VaR model, for three reasons:

- risk factors, or trading locations which are not material in the overall context of the firm may be excluded;
- at any one particular time, a firm may have on its books new products which have not yet been incorporated into the model, or may have a recently acquired subsidiary;
- reliable input data may not be available for some markets, and therefore assessment of capital requirements under the standard rules may be more appropriate for those products.

A firm which is still implementing or improving a model may be allowed some flexibility in including all its products in a model. Any such risks which at any one time are not included in the model should be aggregated into the regulatory capital requirement for the firm under a standard rules approach.

Supervisors should aim to minimise the impediments to innovation in the markets which they regulate. Flexible treatment of new products in the context of value at risk models are of great relevance to this aim.

Whilst some new products can often more comfortably be included within a VaR model than under a standards rules approach, others may be sensitive to a risk factor which is not adequately assessed by the model. In such a case, it may be more practical to permit the firm to determine regulatory capital under the standard approach methodology, or by adding a 'buffer' to the model output, until such times as product volumes require that positions must be included in the scope of the model (ie. on the grounds of materiality).

The ongoing development of a firm's business may mean that in practice, the coverage of a firm's model may never encompass the entire scope of the firm's market risk. In addition, analysis of new products is likely to be time consuming both for the firm and the supervisor, as operational as well as market risks must be given scrutiny.

A firm must agree with its supervisor, as part of the model recognition process, procedures for the inclusion of new products in the model; also changes to any swap and option pre-processing models which form part of the input. Otherwise, new products should initially be included under the standard rules approach. Major changes to a firm's model may require renewed recognition.

Cherry Picking

The standard rules approach of most supervisors is relatively simplistic and is designed to cover risk 'on average', and for a reasonably diversified portfolio. Clearly this means that the standard approach 'overcharges' for lower risk instruments and 'undercharges' for higher risk instruments. A VaR model, however, differentiates. So a firm has an incentive to place lower risk instruments into the model and to retain the use of the standard approach for its higher risk instruments (eg junk bonds). The aggregation of the VaR output and the standard approach capital requirements may then be insufficient. Supervisors should, then, consider the motivation behind any firm's partial modelling – is it motivated by the firm's IT capabilities, or by regulatory arbitrage? Where cherry picking is suspected, the regulator should seriously consider the imposition of an additional capital buffer, and should by this means reduce the incentive for the firm to keep these products outside the scope of its model.

Multiple Entity and Cross Border Issues

Many if not most firms applying for model recognition are likely to form part of a group containing multiple legal entities and trading in several locations. This multiplicity, where the various entities are highly inter-connected, presents a special challenge to supervisors. The group may book risk to the local entity balance sheet from outside the regulatory jurisdiction. In addition, global groups are typically managed along business lines that may not coincide with legal entities, or even geographical boundaries. These issues are not

peculiar to model recognition, but may lead to pressure on a local supervisor to recognise a model which has been permitted by a regulator of other entities within the group.

In this section, the term ‘host supervisor’ is used to denote the local supervisor of an entity in a group whose head office is located in another regulatory jurisdiction. The term ‘home supervisor’ is used to identify the regulator of a firm whose head office is in its own jurisdiction, but which may have overseas subsidiaries and affiliates.

Issues for the Host Supervisor

Whether or not the parent of a subsidiary has been granted model recognition by its home supervisor, a host supervisor will retain responsibility for satisfying itself that the standards for model recognition have been met by the legal entity which it supervises. Overall, the host supervisor will have the objective of evaluating the solvency of that entity. Model recognition is a process by which a supervisor assesses whether the systems and controls which surround a model meet its minimum standards, in the context of the legal entity (or entities) which it supervises and for which it is considering the requisite capital requirements. However, there may be a desire to minimise duplication of effort, by avoiding repetition of work by each supervisor, to the extent that ‘comfort’ may be obtained by other means.

The host supervisor should consider seeking the home supervisor’s views on the firm’s model and the surrounding controls; or may ask to see the information which was supplied to the home supervisor. However, it is also recognised that the extent to which liaison between home and host regulators is possible will be influenced by the availability of information sharing agreements between the respective supervisors. Information shared should include, but not be restricted to, the home supervisor’s minimum scaling factor (ie. the increase in capital required over and above the model calculated VaR), and the reasons behind the scaling factor applied.

It is recommended that supervisors should take care not to allow multinational firms to adopt ‘divide-and-conquer’ behaviour, by obtaining model recognition in several jurisdictions and being permitted to use this as a lever against other local supervisors. Depending upon the type of business undertaken by the local entity (as compared to the model’s strengths and weaknesses) and the adequacy of the local firm’s controls and personnel, there may be valid reasons why model recognition would not be appropriate.

Instruments which form only a proportionately small part of a group’s global portfolio may form a significant element of the risk of the local entity. The standards required of the modelling and control of the risks associated with such instruments may properly be subject to greater scrutiny by the local supervisor than by the home supervisor. The local supervisor may withhold model recognition, or may set a higher scaling factor for the calculation of capital required, if the model addresses the specific risks arising from these products less well than the generality of the global portfolio.

Example: a subsidiary incorporated in an emerging market location may concentrate its activities in trading bonds issued in that jurisdiction. Such assets may pose particular challenges for valuation if the asset markets are illiquid. Data series may suffer gaps, or they may not be long enough to use in a VaR model. These issues may be of prime importance to the host supervisor, but may be relatively less material to the home supervisor if they are a small part of the firm’s global portfolio.

Clearly what is most important is that the model is appropriate in nature and in scope to calculate the capital requirements of the entity which is being supervised. If the model cannot be run on the basis of the positions which the local firm holds, it should not be recognised.

The host supervisor's judgement in respect of whether the local entity satisfies its qualitative standards may be even more complex. In a matrix management structure, where the risk management of particular business lines is often strongly centralised, and may cut across legal entity balance sheets, controls may be strong at the 'group' level, but may not focus on the management of risk (or the distribution of risk compared to regulatory capital) at the local entity level. In addition, those with responsibility for group risk management may not come within local supervisory purview.

Many firms find it efficient to centralise their risk management functions within one location (often the head office). Requiring that each of the risk management functions be replicated in the location of each legal entity may be regarded by the firm as excessively costly and inefficient. It may also have an adverse effect upon the strength of group level controls. If they are to recognise models in these circumstances, supervisors may need to devise additional alternative mechanisms for ensuring that the necessary control infrastructure is in place, for example:

- information sharing agreement with the firm's home supervisor;
- if VaR calculations in respect of the local entity are run 'in a black box' located at a centralised risk management function, an agreement with the firm regarding access to, and requirements of, group risk management in relation to the supervised entity.

This will mean that the local supervisor will need to periodically visit the centralised risk management locations, to ascertain that the appropriate level of control is exercised and to obtain regular information from them in respect of the discharge of this function.

The supervisor will need to ensure that the split of local and centralised responsibilities is not such as to compromise the subsidiary's ability to comply with the supervisor's minimum local control and governance requirements, and the subsidiary's ability to determine its own risk exposure.

By whatever means, the host supervisor must be able to satisfy itself that the model is used in conjunction with internal trading and exposure limits, effective to manage the risk of the local legal entity. The daily reports produced by the risk control unit in relation to the local entity should be reviewed by a level of management with the skills and sufficient authority to enforce any reductions of positions of individual traders and of the local firm's overall exposure.

Also, if the firm and local supervisor are to be assured that the model is correctly calibrated for local conditions, backtests must be run on a legal entity basis.

Issues for the Home Supervisor

A Firm with Overseas Subsidiaries and Affiliates

Where the home supervisor is consolidating supervisor, it should discuss with the respective host supervisors of subsidiaries and affiliates, their assessment of controls within those entities, including an assessment of controls surrounding the model (if these are not centralised).

A firm may wish to use an internal model which covers more than one legal entity within a group when calculating capital requirements on a consolidated basis. In this case the supervisor and the firm should agree on a method by which the capital requirements are to be aggregated (ie. the method of consolidation), to ensure completeness of data.

Where a model used in an overseas location differs from that used in its head office, the home supervisor may be able to satisfy itself about the integrity of the model (where the model is material to the global portfolio), and with the firm's reasons for using a different model.

The key task for any home consolidating supervisor will be to ensure that the risk management structure of the firm is appropriate to give adequate oversight of all the different entities within the group, and to ensure that information flows to group risk management are complete, of adequate quality and timely.

A Firm with Overseas Branches

Where a model covers an overseas branch of a firm, the home supervisor will have more direct oversight. Nevertheless the home supervisor will still need to assure itself that the controls are adequate at the branch, even where the model methodology is identical to that used at the head office.

APPENDICES

APPENDIX 1

Further Guidance on Back-Testing

Supervisors generally require VaR models used for regulatory capital purposes to forecast to a high level of confidence (eg a 99% confidence level). This means that, if a firm's value at risk model does succeed in forecasting a maximum loss at a 99% confidence level, occasions on which the firm's portfolio loses more value than the value at risk ('overshootings') should not occur very often: 2.5 times per year on average, if daily VaR is compared to daily P&L. Therefore as a result of their chosen quantitative standard, supervisors can expect only to have a small number of exceptions from which to draw diagnostic inferences regarding the validity of the model.

However, all VaR methods produce as a by-product, not just a 99% confidence level loss prediction, but an estimate of the entire P&L distribution. The whole distribution may be used in backtesting, to increase greatly the power of the test.

Supervisors should note that a consequence of a back-testing regime which feeds the results of the statistical test back into the determination of a capital requirement is that, even for a static portfolio, the firm's capital requirements may be subject to unpredictable change: capital requirements may be subject to a material increase on any given day as overshootings occur; and may decrease from one day to the next as exceptions become 'time expired'.

APPENDIX 2

Further Guidance on Stress Testing

Different firms are vulnerable to large losses in different circumstances. It is not possible to enumerate a set of scenarios under which all firms would suffer their worst loss. A firm which relies on testing a standard set of scenarios, without active judgement, is unlikely to spot the events to which its own portfolio is particularly sensitive.

Since a firm's trading strategies and prevailing market conditions are both subject to change over time, appropriate scenarios for stress testing will also change. Supervisors should expect to see that a firm reviews on a regular basis the scenarios used for testing purposes.

Stress tests should not be restricted to that part of the firm's portfolio which is modelled. Instruments which are subject to a standard rules approach, or instruments which do not form part of the firm's trading book may also be affected. Specific risk effects should also be considered (where the specific risk element of a portfolio is material) – even where the firm's VaR model is used to determine capital requirements in respect of general market risk only.

Large losses are often (but not always) associated with extreme market moves. During times of market stress, more than one market may be affected: the correlations of returns across markets may tend to increase in absolute value, or may behave unpredictably.

Examples:

One form of stress testing is to change certain assumptions within the model in response to defined shocks – eg a 10 standard deviation shift. If a firm's strategy includes the possibility that it may have short positions in a risk factor, that risk factor should be shifted both up and down. The resulting profit or loss should be calculated

Another form of stress testing is a top-down approach, in which hypothetical events are constructed (or which may be based on historical experience). If hypothetical scenarios are used, the firm also has to deduce a plausible and internally consistent set of market moves which it judges could result from such a scenario; a potentially complex and time-consuming task. With either method, the firm must then calculate the resultant impact upon its portfolio value.

Where a value at risk model includes explicit assumptions in relation to the correlations between various risk categories, these correlations should be stressed to ascertain the impact of correlation instability or correlation estimation error upon the value of the firm's portfolio.

If the markets are subject to large corrections, the impact on a firm may not be restricted to the short term change in value of positions in that firm's portfolio: there may be a deterioration in the credit quality of the firm's counterparties; there may be an overall loss of liquidity in the markets; even an operational disruption in the market infrastructure. Market stress scenarios should take some account of such second round effects.

Stress tests should encompass the possibility that firms may face large losses from scenarios that do not imply large market moves:

Examples: non-parallel shifts in yield curves; crossing of barriers for firms with large options portfolios etc.

For portfolios that contain only a small amount of non-linear risk, supervisors may permit firms to use approximations to calculate the profits or losses arising from market moves. However, firms should use full revaluation for portfolios with material non-linear components, as approximations may give a misleading impression of the true pay-off characteristics of these products.

APPENDIX 3

Guidance on Information to be Sought from Firms and the Model Recognition Process

Introduction

Model recognition is a process by which a supervisor assesses whether a firm's model meets its minimum quantitative standards and additionally forms a judgement as to whether the model's operating environment at the firm meets its qualitative standards:

- completeness and quality of data and systems;
- internal controls and verification processes;
- use of the model in the firm's risk management;
- calibre and authority/oversight of the firm's personnel.

The means by which a model review team covers such an agenda may vary across firms and depending upon whether the regulator has to consider any remote locations (e.g. overseas subsidiaries). Many of the subjects may well be covered by an examination of documentation either prior to or after a visit. However, some of the (qualitative) judgements can only be covered satisfactorily by on-site interviews – particularly where they regard the competence, knowledge and oversight of the firm's personnel.

Given the range of factors to be considered in model recognition, supervisors should seek to meet a range of the firm's staff, including, but not limited to:

- senior management responsible for determining the risk appetite of the firm and overall risk management;
- those responsible for day-to-day risk management and to production of information remitted to senior management;
- front office staff;
- systems development personnel;
- internal audit personnel, particularly those responsible for the verification that controls surrounding the model, and market risk management are operating adequately.

The following areas, while not exhaustive, should be covered by the supervisory process:

Overall Risk Management Organisation and Risk Management Controls

Including: roles, responsibilities and qualifications of key personnel; reporting lines and information flows; authority levels; limits and limit structures; new product procedures; risk management policies; and risk aggregation methodologies.

Supervisors are referred to IOSCO's 1998 Paper: *Risk Management and Control Guidance for Securities Firms and their Supervisors* for additional guidance in this area.

Control Verification

Supervisors should seek to review the operation of the firm's internal audit function as this is the firm's internal means of checking that controls are operating as prescribed. This should include its independence levels from front office and risk management functions, the expertise of its staff and the methodology by which it conducts its examinations as well as frequency. The unit's reporting line (preferably to the firm's senior management) should also be considered.

Supervisors should seek to review output from this function, both to evaluate its quality and to review what actions the firm has taken in response to recommendations made, or problems highlighted.

The Model, its Parameters, Assumptions, Inputs and Outputs

The supervisor should require information on, or evidence of:

High Level Issues

Rationale for seeking VaR recognition; use to which the VaR model is put (limit setting, position management, calculation of capital requirements or allocation etc)

Inputs, Positions and Risk Factors

Accuracy and completeness of trade data: (including from remote locations where aggregation and timeliness may be an issue, and how OTC trades are captured). A diagram of the model's feeder systems, including an indication of timing and reconciliation procedures etc.

Valuation systems: including documentation and testing of accounting policies, reserving policies and position liquidity.

Documentation and quality of pricing models (see also below); methodologies used and how these are verified. This should include a list of all pricing models used; documentation of their analytics and coverage of products:

Interest rate risk:

Type and construction of yield curves used in pre-processing and aggregation models; methods for calculating interest rate sensitivity; methods for capturing spread risk; and techniques used to capture net interest rate risks.

Non-linear products:

Supervisors should seek documentation on how the firm incorporates non-linear risks within its VaR model (or else, what other methods of risk measurement and control the firm uses for these products). Information should include the extent of

approximations, eg. Taylor series; construction of volatility curves and surfaces and derivation of option volatility time series; allowance of offset of vega; incorporation of path dependence features; discontinuous pay-offs; correlations; gamma; key assumptions and weaknesses of approaches used.

The VaR Model (Risk Aggregation)

Model Coverage:

risk factors and products captured by the model, including style, maturity, range of underlying instruments and currencies etc. List of products to be excluded from the model, with reasons for exclusion, and indication of materiality. Trading locations not covered by the model and alternative treatment of those not captured.

Methodology:

evaluation of methodologies used; confidence intervals; holding periods; length of historical data series (see also below); key assumptions; model weaknesses; aggregation methodologies across different risk factors, and of inputs; specific risk methodology, if appropriate.

Historical data series and calculation of variance-covariance parameters: length of data series used and data sources; timing of data collection; procedures for cleaning and filling gaps in data series. Method of calculating variance-covariance parameters (where relevant) and reasons for choosing methodology; measures to take into account asynchronous data when estimating correlation (if applicable).

Validation of the Model

Supervisors should seek to check that the model incorporates the risk inherent in the firm's portfolio. Supervisors should ordinarily require the firm to compute VaR for different periods of time and to have some backtesting results for examination before use of the model for regulatory reporting is approved. The supervisor should ensure that the firm undertakes tests additional to any regulatory backtesting requirements. Supervisors are referred to Page 5 of this paper and Appendix 1 for further guidance on the rationale for backtesting.

Description of the methods of backtesting employed; P&L attribution and cleaning procedures; responsibility for cleaning and verification; treatment of options (checking of pricing models; full revaluation?); extent to which back testing is carried out at the sub-portfolio level.

Copies of backtesting reports and circulation lists: Supervisors should seek to see copies of reports distributed to senior management; also the circulation list; timing of information distribution, and frequency.

Use of the Model Outputs: Integration into the Firm's Risk Management

Copies of VaR based market risk reports distributed to senior management; circulation lists; timing of distribution; frequency of availability of VaR information.

Release and Change Control

Copies of procedures manual for release and change control applicable to model, including who has the authority to initiate and to sign off changes made; nature of verification and testing procedures; regulatory notification procedures.

Other Risk Management Information

Much of this is covered elsewhere in this guidance, see: Section I, and Appendix 2 (Stress Testing)

Calculation of Regulatory Capital

Supervisors must, as part of the application process, agree with the firm:

- the application of regulatory standards to model output: this will include that the model output satisfies the relevant quantitative standards; but applicable multipliers and buffers must also be agreed;
- Methods for aggregating the VaR based capital requirement, with any capital requirements determined under standard rules;
- Any additional capital requirements in respect of legal and operational, or other non-modelled risks;
- Key conditions attaching to use of the VaR model for regulatory capital: this may include model scope; product coverage; regulatory notifications requirements, or permission requirements (eg in respect of changes); any reporting requirements (eg for backtesting).