Public version

IOPS RISK-BASED SUPERVISION TOOLKIT

MODULE 2

QUANTITATIVE TOOLS FOR RISK ASSESSMENT

Public version

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Introductory note

The **IOPS Toolkit for Risk-based Pensions Supervisors** provides a 5-module framework for pensions supervisors looking to apply a system of risk-based supervision. A web-based format allows: a flexible approach to providing updates and additions; users to download each module separately as required; and a portal offering users more detailed resources, case studies and guidance. The website is accessible at https://one-communities.oecd.org/community/iops/SitePages/RBS-Toolkit(1).aspx

This document contains the guidance for **Module 2: Quantitative Tools for Risk Assessment**

Public version

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Figure 1: RBS Cycle

I. INTRODUCTION

Risk-based supervision (RBS) is a structured approach which focuses on the early identification of potential risks faced by pension plans or funds[1] and the assessment of the financial and operational factors in place to minimise and mitigate those risks.

This process then allows the supervisory authority[2] to direct its resources towards the issues and institutions which pose the greatest threat thereby supporting timely action and escalation where determined necessary.

A. Purposes

Module 2 of the IOPS RBS Toolkit deals with the tools that can be used by a pension supervisory authority in the quantitative assessment of risk. Quantitative assessments can play an important part in driving the overall risk-assessment process which is at the heart of risk-based supervision. Qualitative assessments, being more subjective, require care to be taken to ensure consistency in outcomes.

Sometimes the supervisory authority undertakes such quantitative analysis itself. However, as such techniques can be time consuming and resource intensive, it could (a) encourage pension funds to conduct this type of analysis and (b) assess the results of quantitative analysis that the pension fund has undertaken.

Quantitative regulatory requirements for pension funds are often the starting point for supervisors who wish to undertake a quantitative assessment of the risks which the funds they are overseeing face. The

[1] According to the OECD's taxonomy, OECD (2005), a pension fund is a legally separated pool of assets forming an independent legal entity that is bought with the contributions to a pension plan for the exclusive purpose of financing pension plan benefits. The plan/fund members have a legal or beneficial right or some other contractual claim against the assets of the pension fund. Pension funds take the form of either a special purpose entity with legal capacity (such as a trust, foundation, or corporate entity) or a legally separated fund without legal capacity managed by a dedicated provider (pension fund management company) or other financial institution on behalf of the plan/fund members.

A pension plan is a legally binding contract having an explicit retirement objective (or – in order to satisfy tax-related conditions or contract provisions – the benefits cannot be paid at all or without a significant penalty unless the beneficiary is older than a legally defined retirement age). This contract may be part of a broader employment contract, it may be set forth in the plan rules or documents, or it may be required by law. In addition to having an explicit retirement objective, pension plans may offer additional benefits, such as disability, sickness, and survivors' benefits. In EU countries, this module may not apply to those pension funds and pension plans that fall outside the scope of the EU Directive 2016/2341/EC of the European Parliament and of the Council of 14 December 2016 on the activities and supervision of institutions for occupational retirement provision (IORPs), e.g. pensions funded via book reserves (c.f. art. 2 of the Directive)..

[2] Pension supervisory authorities referred to in the IOPS Toolkit for Risk-based Supervision are defined as any entity responsible in whole or in part for the supervision of pension funds, plans, schemes or arrangements in a country, or the subdivision of a country, whether invested with its own personality or not.

fundamental purpose of such quantitative regulatory requirements is to assess and limit the risk that pension funds will fail to satisfactorily meet their explicit and implicit obligations to members and beneficiaries. Therefore, they can provide useful benchmarks for supervisory risk assessment.

The use of these quantitative tools can provide a bridge between a more traditional rules-based and a risk-based approach to supervision – and indeed (as discussed in the Introduction to the IOPS Toolkit) the two are not mutually exclusive but complementary. Under a risk-based approach, supervisors need to consider not only whether quantitative regulatory requirements (whether simple quantitative requirements such as basic funding rules or investment restrictions, or 'risk-based' quantitative requirements such as solvency stress and scenario tests and value at risk (VaR) measures) are being met, but whether risks are being identified and managed in such a way that the requirements will continue to be met in the future - even under adverse circumstances. Compliance with regulatory requirements - although necessary - might not be sufficient to provide evidence that risks are being kept at or below a satisfactory level. This is particularly likely to be the case if the quantitative requirements address only some of the risks that are of interest to the supervisor, for example, credit and market risk but not insurance or operational risk.

The results of such quantitative assessments can therefore play an important part in overall risk assessment and, consequently, a risk-based approach to pension supervision. Poor results from these quantitative tests imply higher levels of residual risk at the entity which is being analysed, which the supervisory authority would then factor into its overall risk analysis or risk score.

However, it should be stressed that qualitative judgement is also required to assess the results of these tests effectively. In addition, some factors and issues do not easily lend themselves to qualitative analysis, and supervisory authorities - particularly when initiating a risk-based approach – may be in danger of over-complicating their risk-based framework or making it overly rigid by trying to make all their analysis quantitative. Qualitative judgement will also be required – and indeed is of more use than poor quantitative indicators.[3]

This Module 2 of the IOPS Toolkit provides an overview of risk-based solvency and other quantitative regulatory requirements, and describes various types of models that can be used for risk-assessment – including but not limited to testing current and prospective compliance with such requirements. Practical, worked examples of these tools can be found in the supporting material.

Section 1 of this Module 2 discusses regulatory requirements that can provide the foundation for the quantitative assessment of risk. **Section 2** discusses various approaches that can be used in quantitative risk assessment, both for assessing solvency risk affecting defined benefit pension plans, insurers, and pension entities and for assessing the risks faced by defined contribution plan members and beneficiaries. **Section 3** then discusses how to integrate these tools into an overall risk assessment. The supporting material provides worked examples of the various techniques discussed.

Limitation of Models

Most of the quantitative assessment techniques make use of models. Before launching an analysis of quantitative tools, the merits of such models therefore need to be considered – particularly in light of the shortcomings identified during the financial crisis in some of the models applied in the financial sector. Problems arose as the models did not consider extreme, tail events – such as were experienced in financial markets during 2008/2009. Quantitative, risk-based regulations also proved to be 'pro-cyclical' in such circumstances, so that some supervisory authorities had to use flexibility in their application to ensure that

[3] Module 3 of the IOPS Toolkit provides a further discussion of the use of quantitative vs. qualitative indicators.

funds were not forced to sell assets into declining markets and thereby impact on the markets themselves (i.e. focusing on macro rather than micro prudential supervision).[4]

Some models used in the quantitative analysis of risk can be very simple, perhaps consisting of only one mathematical formula. Other models, such as those used for stochastic stress testing, can be extremely complex.[5] They can incorporate many mathematical equations, involving hundreds of parameters about which assumptions must be made, and use vast quantities of data about the nature of the obligations of a pension entity, the individuals to whom the entity is obligated, and the investments held to satisfy the obligations. It should always be remembered that the more complex the model, the more difficult it is to test. Many such complex models in financial institutions and pensions have been found to be riddled with errors when properly audited.

Many of the models are used to project cash flows of various types and calculate the present value, future values, or volatility of the cash flows or their values. The simpler models take a deterministic approach to the projections, while the most complex models may take a stochastic approach with respect to at least the most significant parameters. Some of the models used in the quantitative assessment of risk will be those that are also used for valuation and solvency calculations.

Three elements are common to almost all models. The first is that they involve a methodology – in other words, an approach selected by the modeller to analyse the situation. Methodologies have evolved over time, for example, to take advantage of the computational power of computers. The mathematical equations incorporated in the model will be consistent with the methodology chosen by the modeller. The second is that models require that assumptions be made about the various parameters that are reflected in the equations. The third is that they use data about the situation in the calculations. The data may be actual information about the liabilities and assets of the pension entity. However, in some cases, the data may be hypothetical information, such as a possible portfolio of investments that is being tested for suitability.

[4] For details of how pension supervisory authorities reacted to the financial crisis see IOPS (2009), Private Pensions and Policy Responses to the Financial and Economic Crisis, IOPS Working Paper No. 9.

[5] In probability theory, a stochastic process, or sometimes random process, is the counterpart to a deterministic process. Instead of dealing with only one possible "reality" of how the process might evolve under time, in a stochastic or random process there is some indeterminacy in its future evolution described by probability distributions. This means that even if the initial condition (or starting point) is known, there are many possibilities the process might go to, but some paths are more probable and others less. Stochastic models, such as stochastic stress tests, therefore consider many different possible outcomes.

Recommendations on Modelling – The Board of Actuarial Standards

The Board of Actuarial Standards (BAS), a past operational body of the Financial Reporting Council (FRC) in the UK released a consultation paper on modelling in November 2008 (BAS 2008). This puts forward a set of generic standards on modelling, covering general principles, what should be modelled, assumptions and data which should be used, and the checking of models.[1] Modelling standards that were approved came into effect from April 2011.[2]

The principle problems with models identified by the BAS fall into three categories:

- *what is modeled and how*: including omitting factors which turn out to be vital, the use of inappropriate data,[3] only using recent data in the development of models and their parameters[4], with models failing to take account of extreme events and modelers all tending to use the same accepted view;
- *understanding the power and limitations of models*: including their use outside their sphere of applicability, hidden assumptions and simply overestimating the power of models which are by their very nature simplified representations of the real world; and
- *operational risks around the use of models*: such as poor documentation, lack of testing, and the misuse of data.

BAS recommendations include that models should:

- sufficiently represent those aspects of the real world that are relevant to the decision makers for which the information will be used;
- include explanations of how the inputs to the model are derived and what the outputs from the model are intended to represent;
- be fit for purpose in both theory and practice; and
- include explanations of the significant limitations of the model.

Notes:

[1] The BAS notes that their discussions on modelling considered not only actuarial models. Their conclusions could therefore be considered broad enough to apply as good practice to all types of modelling.

[2] See https://www.frc.org.uk/consultation-list/2008/consultation-paper-modelling

[3] An example being given of mortality assumptions—using data for populations that have little in common with the populations for whom mortality rates were being derived, taking little accounting of future improvements or reacting only slowing to changing trends.

[4] The BAS (BAS 2008 p5) notes that some financial models had these weaknesses exposed by recent events, as they have not captured the effect of the long-term credit cycle or of sudden market changes.

In short, when using quantitative tools as part of a risk-based approach to supervision, supervisory authorities need to be aware of the limitations of such models and to combine their results with qualitative assessments. An assessment of the model error inherent in the applied quantification, model robustness, documentation of assumptions, use of results for decision making, change controls, the expertise of staff members maintaining the models, the monitoring of outsourced provision for quantitative services by external parties (to name some factors) all need to be checked. It should always be remembered that models – however good - can never be a substitute for the judgement of experienced supervisors.

B. Principles and Guidelines

Several principles and guidelines highlight the need for quantitative assessment of risk, including:[6]

Quantitative Risk Assessment: Principles and Guidelines

IOPS Supervisory Principle 5: Risk-based Supervision

Pension supervisory authorities should adopt a risk-based approach

5.8 Where quantitative risk assessment tools are used, the models involved should be carefully designed and their limitations fully understood.

OECD Core Principle 4: Investment and risk management

Increased reliance on modern and effective risk management techniques and industry-wide risk management standards for pension funds and pension entities should be promoted. The development of asset liability management techniques should be given proper consideration.

IOPS Supervisory Assessment Guideline 5: Risk Assessment Process

In addition to checking compliance, the pension supervisory authority should assess pension funds for the level of risk posed to their members and beneficiaries and the pension system as appropriate.

Risk-scoring systems, using consistently applied quantitative and qualitative factors, may be used, assessing risk in the context of both potential impact and probability of occurrence.

[6] See IOPS Principles of Private Pension Supervision (IOPS, 2010a), OECD Core Principles of Private Pension Regulation (OECD, 2016) and IOPS Guidelines on Supervisory Assessment (IOPS, 2008).

SECTION 1: QUANTITATIVE REGULATORY REQUIREMENTS[7]

Quantitative regulations are the starting point for the quantitative analysis of risk. These can be straight forward limits (such as minimum funding rules for defined benefit (DB) funds or investment restrictions for defined contribution (DC) funds). Alternatively, these quantitative regulations can be risk-based themselves (e.g. factor based solvency rules, VaR calculations).

Risk-based supervision can incorporate these quantitative regulations into the overall risk-assessment process in the following three ways:

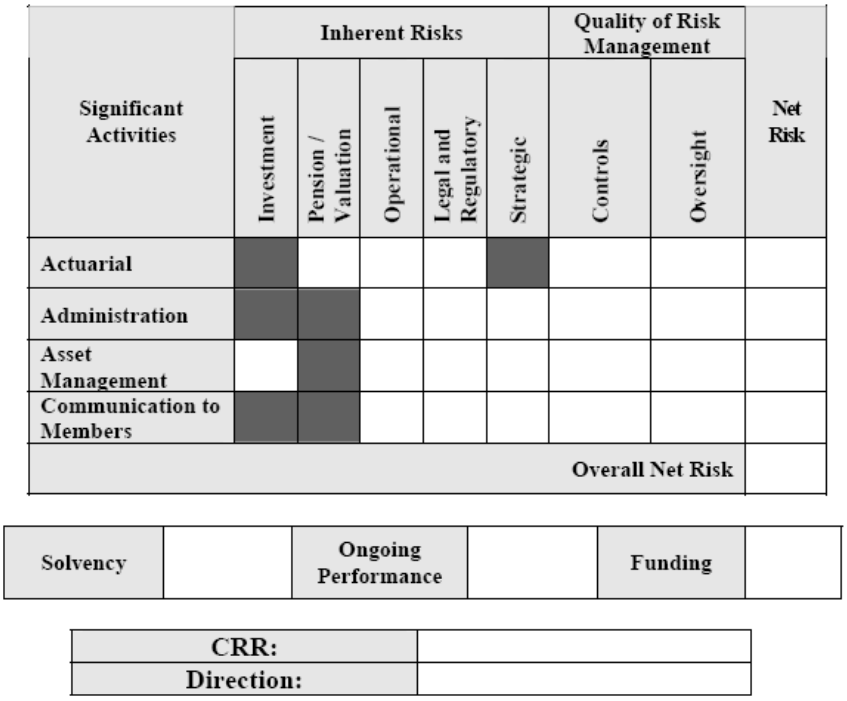
- the simplest fashion is to combine a 'rules-based' and a 'risk-based' approach – compliance with quantitative restrictions is checked, and if not met, a lower score would be factored into the overall risk assessment of the fund;

- alternatively, these straight forward quantitative requirements could be made more 'risk-based' by testing whether compliance would still hold in adverse circumstances (i.e. by stress testing) - the results of these stress-tests would then be incorporated in the overall risk score;

- where the quantitative regulations are already risk-based (e.g. with the De Nederlandsche Bank in the Netherlands and the Office of the Superintendent of Financial Institutions (OFSI) in Canada the risk-based supervision of solvency is central to their risk orientation), compliance with these risk-based regulations would be fed into the overall risk score (e.g. see solvency and funding boxes in OSFI risk matrix below).

[7] It should be noted that in some circumstances the quantitative regulations discussed (such as VaR or other stress tests) are not strictly required by regulation but are used as internal risk measures by supervisory authorities or pension funds themselves. The results of such tests, though not requiring regulated action if broken, would be fed into the overall risk assessment of the supervisory authority as discussed.

Figure 1: OSFI Risk Matrix



Significant Activities	Inherent Risks					Quality of Risk Management		Net Risk
	Investment	Pension / Valuation	Operational	Legal and Regulatory	Strategic	Controls	Oversight	
Actuarial								
Administration								
Asset Management								
Communication to Members								
Overall Net Risk								

Solvency		Ongoing Performance		Funding	

CRR:	
Direction:	

Source: Office of the Superintendent of Financial Institutions

Sometimes these assessments form part of a risk-score for an individual pension fund. Other pension supervisory authorities add such tests as a separate 'layer' on top of their qualitative risk score (as described in Module 5 of the IOPS Toolkit). Such assessments can also be aggregated to provide an overview of systemic risk (e.g. funding levels for the pension system as a whole).

Section 1 of Module 2 of the IOPS Toolkit looks at the regulatory requirements that form the basis of quantitative risk assessment.[8] It discusses the valuation, risk-based solvency, and investment risk

[8] Many regulatory requirements are intended to limit the risks assumed by a pension entity, ensure that the risks assumed are assessed and managed adequately, or require that sufficient financial resources exist to enable the entity to meet its obligations even if adverse conditions occur. If well designed, such requirements will be targeted at the most relevant risks and will be sufficiently flexible to enable compliance by entities in different circumstances, for example, both large and small pension plans and funds.

Some of these requirements are operational in nature. In other words, they are designed to restrict actions that may be taken in managing the affairs of the entity. Examples of such requirements are regulations on asset quality, mix, volatility, and liquidity, asset-liability matching, and the nature of benefits and guarantees that might be provided. Other regulatory requirements are more financial in nature. They are not designed to directly control the day-to-day operations of a pension entity. Instead, they are designed to ensure that the entity has valued its assets and liabilities appropriately, and that its assets will be sufficient to meet its liabilities—both currently and prospectively, often with margins for adversity.

Appropriate valuation is essential to the quantitative assessment of the current financial position of a pension entity. Where applicable—depending on the type of entity—it also provides a foundation for applying minimum funding requirements and for calculating factor-based solvency requirements, along with a starting point for the determination of solvency requirements based on stress scenarios. Appropriate valuations are

requirements that can provide the foundation for the quantitative assessment of risk within DB pension plans, insurers, and pension companies. The objective of such requirements is to ensure that a pension entity has the financial capability to meet its obligations to members and beneficiaries at all times, even under adverse conditions. They include the following: valuation requirements; comparison against experience; quantitative investment requirements to which minimum funding requirements such as factor-based solvency margins and stress-related solvency margins can contribute.

This Section then goes on to discuss various types of requirements that have been developed to limit the investment risk to which members and beneficiaries in a DC pension plan or fund are subject, and which some supervisory authorities also incorporate in their risk-assessment approaches.

As explained, such regulatory requirements are often the starting point for supervisors who wish to undertake a quantitative assessment of the risks which the entities they are overseeing face. Module 2 of the IOPS Toolkit presents an overview of the types of requirements that exist, to provide context for their use in supervisory authorities' quantitative assessment of risk. Sometimes, more than one type of requirement might apply to a particular pension entity, and the module indicates the types of entities to which various requirements are commonly applied. However, the design of such requirements is a complex regulatory matter, which will not be dealt with here.

1. Regulatory Requirements for Defined Benefit Pension Plans[9]

In terms of DB pension plans, the main financial risk which regulation is protecting against is solvency or funding risk. Regulatory requirements which can be applied to deal with this risk are described below. Many of these types of requirements are also commonly applied to insurers and pension companies, and are sometimes relevant to DC plans - particularly those that provide guarantees.

Valuation Requirements

It is essential that the bases to be used in valuing the assets and liabilities of pension entities be clearly, consistently and appropriately defined. Without proper valuations, risk assessments (whether to establish compliance with regulations or for other supervisory assessments) cannot take place. In some jurisdictions, the detailed requirements are set out in regulations. In others, the valuation requirements are established by reference to professional standards. For example, the legislation might require that assets be valued in accordance with International Financial Reporting Standards (IFRS) and that liabilities be valued in accordance with local actuarial standards.

Valuation requirements are relevant to all types of pension entities. However, the valuation of liabilities under defined benefit plans is much more complex than for defined contribution plans.

The assets of DB plans are often valued at market values (although there can be different underlying valuation principles, e.g. for balance sheet items and solvency). The aim is to ensure an economic valuation. In some jurisdictions, however, some assets might be valued at amortised cost or using smoothed market values. Although such non-market valuation bases can help to avoid abrupt changes in required contributions, they can also complicate the assessment of risk by obscuring the current value of assets. The usefulness of valuation results for both financial and risk assessment is generally enhanced if the basis used to value the assets is consistent with the basis used to value the liabilities. For example, assets and liabilities

consequently also essential for supervisory authorities who wish to conduct quantitative risk assessment based on these requirements.

[9] See also IOPS (2021a), Supervision of solvency of occupational DB pension funds, IOPS Working Paper No. 35.

might both be valued using market values and market interest rates,[10] or they might both be valued using some smoothing mechanisms. However, mixing market valuation of assets with smoothed valuation of liabilities - or vice versa - can be problematic. The purpose of the valuation, as discussed below, often influences the approach that is used.

A fundamental decision that must be made before valuing the liabilities of a DB plan is whether the valuation will be done on a going concern basis or on a liquidation basis. *A going concern valuation* assumes that active members will continue to accrue benefits in the future, eventually leaving employment through termination, retirement, death, or disability. The actuary makes assumptions about future experience and uses these assumptions, along with data about the members and beneficiaries and the benefits they have already accrued, future contributions and the benefit rules of the pension fund and plan to project the benefits that might be paid in the future. The present value of projected future benefits is calculated by discounting the projected payments with interest. The difference between the total value of assets and the total value of liabilities for all members and beneficiaries is the fund's and plan's surplus or, if negative, its deficit.

A valuation prepared on *a liquidation basis* differs in that no additional benefits are assumed to accrue after the valuation date and that the pension fund and plan settles all of its obligations at that date. The rules of the pension fund and plan or regulations may affect the benefits that would be payable on liquidation, in some cases increasing the cost of benefits (for example, by providing full and immediate vesting) and in other cases decreasing the cost (for example, by eliminating the need to provide future indexation of pensions and/or salary increases).

Sponsors of pension plans tend to focus on going concern valuations, which should provide a reasonable picture of the plan's financial position and contribution needs, on the assumption that the plan will continue to operate indefinitely. While supervisors share this interest in going concern valuations, they often have a greater interest in liquidation valuations than do the plan sponsors. Liquidation valuations provide a clearer picture of the financial position of a pension plan should it need to cease operations, for example, because of the insolvency of the plan sponsor. In some jurisdictions, both types of valuations are required.

Valuation requirements should indicate the items that must be valued. This will certainly include the basic benefits payable on termination of employment, retirement, death, or disability. Some types of benefits might or might not be explicitly reflected in the valuation of liabilities. They include embedded options (such as guarantees or alternative forms of retirement pension), indexation of pensions (which might be discretionary or contingent on fund performance), bonuses, and discretionary benefits (such as a favourable early retirement pension payable only with the employer's consent). Depending on how the costs of administering the pension fund and plan are being paid, the valuation of liabilities might also need to provide for future administration expenses.

Valuation requirements sometimes specify key assumptions. For example, a maximum discount rate might be specified, or the basis for determining discount rates might be described (such as the yield curve for zero-coupon bonds, calculated using Euro swap rates). Other assumptions that are often important when valuing defined benefit liabilities are the rates of mortality and mortality improvement, morbidity, employment termination, retirement, salary increases, and inflation, and the proportions of fund and plan members and beneficiaries who are married. Although regulations and actuarial standards may provide guidance on the establishment of such assumptions, the specific assumptions should be appropriate to the circumstances of the pension fund and plan and are thus often determined by the actuary.

[10] One reason for underfunding of DB plans is the declaration of interest rates on a non-market basis - as a fall in assets can therefore cause them to be below the accumulated value of accounts. This practice is to be discouraged, but is unfortunately relatively frequent.

Although the valuation of liabilities would often be built on the best estimates of future experience, it is common to include margins for potential adverse deviations (including the uncertainty of the valuation) in the experience. Sometimes the margins are established implicitly, by using more conservative assumptions than the best estimates. In other cases, the valuation requirements may state that explicit margins are to be established and specify how they are to be calculated.

Most quantitative risk assessment techniques are integrally linked to the valuation of assets and liabilities, and therefore the regulatory requirements related to valuation. Examples include the comparison of valuation assumptions, sensitivity testing of changes in valuation assumptions, and stress testing of risks such as high inflation - the results of which can differ significantly depending on the valuation requirements, for example, whether or not the potential costs of pension indexation are required to be fully reflected in the liabilities.

Minimum Funding Requirements

The valuation of a DB pension plan will seldom show its assets precisely equal to its liabilities. There might be a large surplus of assets over liabilities, in which case regulations and pension fund and plan rules might permit contribution holidays or the distribution of part of the surplus to members and beneficiaries or the sponsoring employer. If there is a large deficit of assets compared to liabilities, the members and beneficiaries face a heightened risk that they might not receive all of the benefits to which they are entitled. In most jurisdictions, pension funds with unfunded liabilities would need to have their assets augmented over time to reach the funding target. There could be specific rules for this, or the legislation might simply require the fund management to file and conform to a "recovery" or "remedial" plan.[11] Sometimes the level of assurance is increased by the provision of an employer covenant to pay additional assets if and when they become due.

Minimum funding requirements have the objective of ensuring that a pension fund or plan has sufficient assets to meet its liabilities. Sometimes, the level of assurance is increased by requiring assets to exceed liabilities by a solvency margin. The solvency margin might be calculated as a simple percentage of liabilities (for example, 10 percent), or be calculated using risk-related factors or stress tests (see below).

If a pension fund or plan is already at or above the minimum funding level, future contributions must be at least high enough to keep it above the minimum funding level. If not, future contributions must be made which are high enough to enable it to achieve the minimum funding level within a specified period of time. Minimum funding requirements may be based on either going concern or liquidation valuations, or both. For example, a funding deficiency under a liquidation valuation might need to be amortised over a period of three years, while 10 years might be provided to amortise a funding deficiency under a going concern valuation.

Minimum funding rules can be incorporated into an overall risk assessment either by checking for compliance (and scoring the fund accordingly) and/or by stress testing the funding position to see if the

[11] For example, the Pensions Regulator in the United Kingdom does not apply a standard set of minimum funding rules. Rather they adopt a 'scheme specific' approach to funding. The pension supervisory authority then checks whether the assumptions which are included in these technical provisions and whether recovery plans (required to repair a deficit and meet a scheme's funding objective) are set prudently. For details of the United Kingdom's approach, see https://www.thepensionsregulator.gov.uk/-/media/thepensionsregulator/files/import/pdf/employer-covenant-statement-june-2009.ashx A new defined benefit funding code is expected to come in force 1 October 2023; the new code still does not intend to introduce 'Minimum Funding Requirement' type regime – c.f. https://www.thepensionsregulator.gov.uk/en/document-library/consultations/draft-defined-benefit-funding-code-of-practice-and-regulatory-approach-consultation/draft-db-funding-code-consultation-document

minimum requirements would be met under adverse circumstances (with the results of such tests fed into the risk score). Checking the assumptions included in the calculation of funding positions and recovery plans is also key (as is the case in the UK example – see footnote 11).

Factor-based Solvency Margins

Solvency margins can be made risk-based by requiring higher amounts of capital to be held against risky assets (such as equities), thereby providing a buffer in case such assets decline in value. Solvency margins for pension entities are sometimes calculated by applying risk-related factors to various proxies for the asset and liability risks faced by the entities. The objective of factor-based solvency margins is to adjust the required margin in accordance with the risk profile of the entity, having regard to the scale of the risk. They provide a relatively simple and standardised means of doing so.

For example, a factor of zero might be applied to cash and bank deposits (i.e. no additional capital is required to be held), a higher factor (i.e. additional capital requirements) to corporate bonds, and an even higher factor to common equities and real estate holdings. The amounts calculated with respect to each type of risk (such as credit risk, market risk, and insurance risk) are often just added to one another to determine the total required solvency margin, but are sometimes combined using a formula (such as squaring the amounts for each type of risk, summing the results, and taking the square root of the sum) to reflect expected diversification effects.

This approach is consistent with the risk-based capital requirements applicable to banks and insurers in many jurisdictions. It can be used for pension entities and the pension business of insurance companies. It can also, as noted above, be used for calculating the solvency margin required of a defined benefit pension plan or a defined contribution pension plan that offers guarantees (although this will not provide a scientific estimate of the real potential cost of the guarantee). Again, either straight forward or stress-tested compliance with these margins can be incorporated into an overall risk score

Stress-related Solvency Margins

Although factor-based solvency margins attempt to reflect the risk profile of a pension entity, they necessarily involve approximations and averages, and might not provide a close estimate of the solvency margin that a particular pension entity would need to withstand adverse conditions. Stress-related solvency margins overcome this weakness by requiring each entity to calculate the additional amount of assets it would need to be able to meet its obligations under a prescribed stress scenario or scenarios.

The scenario or scenarios might be described in regulation or be specified by the supervisory authority. The assets and liabilities of the pension entities would be recalculated using assumptions consistent with the prescribed scenarios. The difference between the net positions under the stress scenarios and the assumptions would constitute the required solvency margin.

The requirements sometimes utilise two levels of stress, mild and severe. The supervisory actions taken with respect to pension entities whose solvency margins are inadequate to withstand even the mild level of stress would be more intensive than the actions with respect to entities that can withstand the mild level of stress but struggle at more severe levels of stress. An example of a jurisdiction with such requirements is Denmark.

This approach can be used for pension entities and the pension business of insurance companies and for calculating the solvency margin required of a defined benefit pension plan or a defined contribution pension plan that offers guarantees. It might be used instead of factor-based solvency margins. However, because of the additional calculation effort involved, it might be used in combination with a factor-based approach

(for example, small and strongly-funded plans can use factors while larger and poorly-funded plans must calculate stress-related margins – in other words, the approach required should be based on the level of risk).

The results of these stress tests would then be fed into the overall risk assessment or risk score for a fund.

Table 1: Risk-based Solvency Requirements

Country	Measurement of Liabilities (Technical Provisions)		Minimum Solvency Requirements	Solvency Buffers
	Treatment of Longevity Risk	Discount Factors		
Netherlands	Group specific mortality table adjusted for predicted longevity improvements, plus buffer to address uncertainty in predicted values.	Risk free term structure with UFR based on moving average forward rate.	4% (plus possible add-on) of Technical Provisions (from EU IORP Directive). Measured once per year using current market values. Compliance to be restored within 6 months if the so-called *policy funding ratio* (moving average over the past 12 months) has been below the minimum funding requirement for 5 consecutive years.	Maximum probability of underfunding within 1 year measured with stress test: 2.5%. Solvency buffers determined by risk factors specific to each asset class. Example of risk factors include yearly decline in: equity 30-40% (depends on type); currency 20-35%; real estate 15%. Maximum period for correction of deviations: 10 years.
Denmark	Fund-specific mortality table approved by actuary and supervisor. Traffic light stress test includes assessment of the impact of a 10% improvement in longevity. The traffic light system, since the introduction of Solvency II in 2016, applies only for the few very small and old company-related pension funds[12].	Market yield curve measured by Euro swap curve.	Solvency margin defined by EU Life Directive: 4% of Technical Provisions plus 0.3% of risk bearing investments. Measured quarterly using current market values.	Traffic light system is a stress test rather than part of the formal solvency rule, but results are taken into consideration in the supervisory assessment. Test defines 3 zones: green, yellow, and red. Final outcome depends on whether entity remains solvent after test. Example (year variations): listed equity: red 12%, yellow 30%; interest rate (medium duration): red +/- 0.7pp, yellow +/- 1.0 pp parallel shift of the curve.
Mexico	No formal liabilities in DC plans.		No formal solvency requirements, but VaR limit designed to limit downside risk for DC members. Historic VaR calculated with rolling 1000 day sample at 5% significant with different limits imposed on two portfolios. Price vector provided by two independent vendors. Highest risk portfolio: no limit.	

[12] They represent 1% of the funded Danish pensions. 8o% of entities are regulated by Solvency II and the remaining share relates to ATP that has its own regulations.

Country	Measurement of Liabilities (Technical Provisions)		Minimum Solvency Requirements	Solvency Buffers
	Treatment of Longevity Risk	Discount Factors		
			Most conservative portfolios: 1.10% - 0.70% maximum daily loss.	

Source: (Brunner et al, 2008) with updates by the Secretariat.

Example: Germany

Supervisory authority BaFin in Germany has established a stress testing program for *Pensionskassen.* All Pensionskassen are expected to participate in the stress testing program. However, in the case of small entities with low-risk assets, BaFin may exempt individual undertakings.

The stress test approach:

- simulates a short-term, adverse capital market change
- considers the effects on the balance sheet and economic impact
- projects the ability of the Pensionskassen to meet Solvency I capital requirements and liabilities within one year under four different stress scenarios

The stress scenarios used include:

Scenario 1: Interest rate stress (-10 %)
Scenario 2: Equity stress (in 2021: -41 %)
Scenario 3: Combined interest rate stress (-5 %) and equity stress (in 2021: -22 %)
Scenario 4: Combined property stress (-10 %) and equity stress (in 2021: -22 %)

2. Regulatory Requirements for Defined Contribution Pension Plans[13]

Investment risk is the key risk that needs to be considered with DC pension plans and funds. Various approaches are used to limit the investment risk to which pension funds and plans are exposed. Many factors can influence the approach taken, such as the type of pension system (for example whether mandatory or voluntary), the broader context in which the pension plans are operating (the level of development of the capital markets, the level of financial literacy of the members and beneficiaries, etc..), and the regulatory philosophy (such as the relative reliance on principles versus rules). [14]

The main quantitative regulatory requirements which can be applied to DC pensions are as follows. As with quantitative requirements for DB funds, a risk-based supervisor would consider compliance with these quantitative limits as part of their overall risk assessment for DC funds. [15]

[13] As noted, these quantitative tests may not be legal requirements but used as internal risk measures either by supervisory authorities or by pension funds themselves.

[14] Details of the different mechanisms for controlling investment and other risks within DC pension plans can be found in IOPS (2010b), Managing and Supervising Risks in Defined Contribution Pension Systems, IOPS Working Paper No. 12.

[15] It should be noted that some of these limits, such as investment limits, may also apply to DB plans.

Investment Limits[16]

Many supervisory authorities have an important role in enforcing a quantitative approach to controlling investment risk within DC pension plans, by checking that plan asset allocations do not breach quantified limits on various asset classes or restrictions on the proportion of assets that may be held with a single issuer (to avoid risk concentration).

These quantitative rules can be combined with a 'prudent person' approach to controlling investment risk.[17] Investment limits by themselves do not ensure that an investment is 'prudent'. Therefore, in most countries quantitative limits and the more qualitative prudent person rule are combined (and indeed should not be seen as incompatible).

Supervisors overseeing DC funds still have to consider whether the investment approach is appropriate, even where more quantitative restrictions are put in place. As discussed in Module 1 of the IOPS Toolkit, some countries which still rely heavily on quantitative limits have integrated these into a risk-based approach to supervision. The supervisory authority consequently monitors investment risk according to whether pension funds are invested within the quantitative limits set. Non-compliance will be added to the overall risk score within the risk assessment part of the risk-based supervision process. By way of comparison, other risk-based supervisors use only the prudent person test, feeding the results of their assessment directly into their overall risk scores – i.e. assessing investment risk in qualitative rather than quantitative terms.

Some regulators have made their quantitative investment limits more 'risk-based' by adapting them to the risk-appetite, or age of investors. Regulations might also seek to limit risk by restricting the investment choices available to members and beneficiaries. Relatively conservative default options are sometimes specified, or the choice of fund might be restricted depending on the age of the member or beneficiary – i.e. what is known as 'life-cycle investing'. In building their overall risk-assessment, risk-based supervisors would analyse whether the funds offered by a pension provider comply with such requirements, whether the performance is in line with their peers, the composition of the portfolios making up the investment options and other qualitative assessments of the pension fund manager's ability.

Table 2: Equity investment limits by type of fund investment option in selected countries[1]

	Option 1	Option 2	Option 3	Option 4	Option 5
Chile[2]	40%-80%	25%-60%	15%-40%	5%-20%	0-5%
Mexico	60% decreasing quarterly up to 15%				
Hungary (private pension funds)	100%	40%	10%		
Estonia	50%	25%	0%		

Source: OECD

Note: (1) Selected countries have mandatory 'pure' DC systems (2) In Chile, equity investments in each fund option are subject to both a floor and a ceiling.

[16] See OECD (2022) and yearly editions available at https://www.oecd.org/finance/private-pensions/annualsurveyofinvestmentregulationofpensionfunds.htm.

[17] Indeed, OECD (2006), the OECD Guidelines on Asset Management, outlines how the two can be combined. See also discussion on prudent person rule in Module 1 of the IOPS Toolkit.

Minimum Return Limits (i.e. guarantees)

An alternative way of controlling investment risk within a DC pension (i.e. preventing adverse return outcomes and consequently a low accumulated pension balance) is to require a guaranteed return on the fund. Such requirements might be in the form of an ***absolute*** minimum rate of return or a ***relative*** minimum, set in relation to the industry's average rate of return over a certain period (usually a few months). The investment decisions of the pension fund managers will be strongly influenced by the need to achieve the required minimum returns.

Guaranteed minimum returns impact substantially on the nature of the supervision of the system, as the solvency of the provider becomes a major issue and some form of solvency supervision, as found in DB, is required. Such solvency assessment tests (whether compliance or risk-based) would be built into the overall risk-analysis of the fund.

The assets of defined contribution plans, as a matter of principle, should be valued at market values. This is sometimes easier said than done, because certain types of assets might not be traded regularly in the market. The liabilities of defined contribution plans are generally the total of the values of the members and beneficiaries' accounts, determined at market value. However, this becomes more complicated if a defined contribution plan offers any guarantees, such as a minimum rate of return on investments. In such cases, the guarantees would be valued similarly to liabilities under defined benefit plans. In fact, the valuation of investment guarantees is more complex than actuarial valuations of defined benefit pension plans, where deterministic methods are generally adequate. Because guarantees depend on future states of the financial system, and often on the performances of other pension funds in the system, to properly value such guarantees requires complex stochastic methods, using option pricing models would be necessary – there are no simple approximations. Such models have been developed for insurance and other capital market instruments of this nature. They are likely beyond the capacity of both practitioners and supervisors in many countries. The *conseil de perfection* is that such guarantees should not be offered if they cannot be priced, valued and mitigated; nonetheless they appear to be commonplace and have on occasion had devastating effects (see Section 3 of this Module 2)[18].

Value at Risk Limits

One risk assessment technique, described in Section 2 of this Module, is the calculation of *value at risk* (VaR), which can be used to assess the potential volatility of investment results. Results of these tests would be considered as part of the overall risk assessment of the fund. Another form of direct restriction is the establishment of quantitative risk limits on the overall fund portfolio, such as the VaR ceilings used in Mexico. Compliance with such ceilings forms part of the risk-based assessment of the supervisor.

The main attraction of the VaR is that it provides a common measure of risk across different positions and risk factors and introduces an aspect of probability. However, it does not consider losses or gains when the bad state does not occur nor does it say anything about the expected loss when the bad state occurs. Hence, as Dowd and Blake (2006) point out, ignoring tail losses can lead to some perverse incentives (whereby high return, high risk investments may be favoured if they do not affect the VaR – regardless of the sizes of the higher expected return and possible higher losses).[19] VaR has several drawbacks as a risk measure, including:[20]

[18] See also Cohen and Biolodeau (1996).

[19] Dowd and Blake (2006) also discuss other problems, such as subadditivity, which undermines VaR as a risk measure.

[20] See Berstein and Chumacero (2008).

- When measuring pension risk there are at least two important factors to consider: the investment horizon and the risk of annuitisation. VaR models with a time horizon of one day, one month or even one year are not best suited to measure pension risk.

- Critical events: it is not straightforward to predict critical episodes, and when they happen, it might be the case that following a VaR approach can be a potential source of significant instability in the market.[21]

- VaR does not reflect downturns and involves inertia which leads to an over-representation of past volatility.

Given the VaR has many limitations, variations on VaR which are more sensitive to the shape of the loss distribution and the tail of the distribution are being explored. Also known as Expected Shortfall,[22] Conditional Tail Expectation (CTE) is a statistical risk measure that provides enhanced information about the tail of a distribution above that provided by the traditional use of percentiles. Instead of only identifying a value at a particular percentile and thus ignoring the possibility of extremely large values in the tail, CTE recognises a portion of the tail by providing the average over all values in the tail beyond the CTE percentile. Therefore, for distributions with "fat tails" from low probability, high impact events the use of CTE will provide a more revealing measure than the use of a single percentile requirement.[23] However, the accuracy of all such measures needs to be treated with caution as they were designed for solvency assessments of banks – institutions with short-term horizons and exposed to potential liquidity scares. Whether they are appropriate for pension funds – which are long-term investment vehicles – needs to be considered.

The Comision Nacional del Sistema de Ahorro para el Retiro (CONSAR) in Mexico have adapted their model to alleviate another key problem with the VaR system which is its pro-cyclicality. During the volatile markets of 2008/2009, pension funds in Mexico found themselves forced to sell risky assets (i.e. equities) into falling markets at the same time in order to bring their portfolios back in line with VaR limits. A waiver to this rule did exist and was applied by CONSAR, and has since been formalised to reduce the pro-cyclicality during volatile markets in future. Benchmark portfolios have been set up and when increased volatility causes these portfolios to hit their maximum loss limits, the confidence intervals applied to the VaR model will be raised (though the absolute loss limits - ranging from 1.10% to 0.70% for the most conservative portfolios) so that the number of adverse scenarios allowed will be increased in increments of 5 as necessary (i.e. from 26 under the 95% confidence interval, to 31, 35, etc..). Once market volatility returns to normal levels, the 95% confidence interval will be automatically restored.

[21] Hence current regulation in Mexico considers waivers for the funds which risk excess is due to systemic risk. These waivers are granted to prevent unnecessary sales (consequence of the market downturns) which will turn into losses and create instability in the market as well.

[22] Terminology in this area is non-consistent with such measures also referred to as Expected Tail Loss, Tail Conditional Expectation, Conditional VaR, Tail Conditional VaR and Worst Conditional Expectation, Dowd and Blake (2006).

[23] See American Academy of Actuaries http://actuary.org/pdf/life/varwg_march07.pdf and Dowd and Blake (2006).

Table 3: Use of Quantitative Restrictions for Private Pension Plans

	Quantitative investment restrictions by asset class	Minimum investment return (absolute)	Quantitative risk limits
Australia	×	×	×
Chile	✓	×	×
Colombia	✓	✓	×
Denmark	×	×	×
Estonia	✓	×	×
Hungary	✓	×	×
Israel	✓	×	×
Mexico	✓	×	✓
Poland	✓	×	×
Slovak Republic	✓	×	×
Russian Federation	✓	×	×
Sweden	×	×	×
Switzerland	✓	✓	×

Source: OECD (2022) – Annual Survey of Investment Regulation of Pension Funds and Other Pension Providers – 2022 edition

Target-based Risk Measurements

New measurements of risk within DC pension funds are trying to move away from short-term investment returns as it is argued that these are not appropriate measures for a pension fund – the goal of which is to provide a stable retirement income over a long-term time horizon. [24] Indeed, Impavido et al (2009) state that investment risk is amplified by the lack of long-term targets for pension fund managers, compounded by the lack of connection between the accumulation and decumulation phases, exposing individuals to annuitisation risk.[25]

It is therefore suggested that government policy should set long-term investment targets, such as replacement rates.[26] Once these have been set, optimal portfolios for achieving this target would be derived (using stochastic modelling techniques). The performance of the actual portfolio of a pension fund could then be assessed vs. this optimal portfolio which would be used as a benchmark.

It should be noted that this is a new area of research, as yet untested, and is consequently controversial. The challenge is devising the appropriate benchmark portfolios, which could be done by an expert commission consisting of regulators and supervisors, academics, industry representatives, etc. Several defaults, based on a model set of life-cycle pension funds, would have to be derived - reflecting not only age but also so called 'human capital' issues, such as income levels and job stability, etc. The World Bank publication (Hinz et al 2010) notes that these benchmarks should consider the following factors:

[24] For details see Hinz et al (2010).

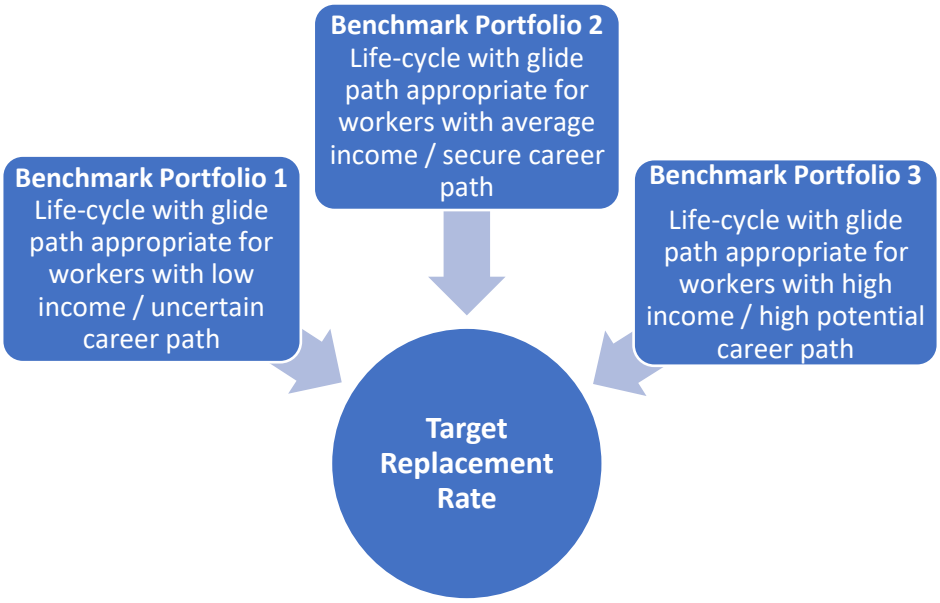
[25] The authors argue that this problem stems from members poor understanding, allowing pension fund managers too much market power.

[26] The replacement rate is the ratio of pension income to pre-retirement earnings. Impavido et al (2009) argue that a cash balance target with specific investment rules aimed at smoothing the interest risk associated with the transformation of cash balances into annuities could probably be a valid alternative. See also IOPS (2015), The Concept of Target Retirement Income: Supervisory Challenges, IOPS Working Paper No.25 for an overview of the concept of target retirement income.

- the presence of other sources of retirement income, including the income from public pensions;
- the age of individuals;
- the rate of contributions;
- the target replacement rate and its downside tolerance;
- a matrix of correlations between labour income and equity returns;
- the expected density of contributions for different categories of workers;
- the type of retirement income in the pay-out phase, in particular the risk tolerance of pensioners in the pay-out phase (e.g. real fixed annuities, variable annuities, and phase withdrawal); and
- a parameter that reflects the risk aversion of policy makers.

The regulator would define the number and structure of lifecycle funds to be offered, with their asset allocations and 'glide paths' (i.e. how rapidly risky assets are reduced) reflecting the objectives of the pension system (the larger the role of these DC funds in the overall pension system the more conservative they would need to be). These benchmarks would indicate different (more or less risky) routes to achieving target replacement rates. Pension fund managers would offer funds in the same category as these benchmark funds, with their returns being measured accordingly.

Figure 2: Target-based Risk-Measures for DC Funds



Source: IOPS Secretariat

The passive implementation of the benchmark (based on objective stock and fixed income indexes) would provide managers with a minimum performance that they might try to improve upon. In the World Bank publication (Hinz et al 2010), Viceira notes that regulators could limit the level of 'active bets' that managers could take by defining (measuring and verifying) maximum tracking errors,[27] just as institutional

[27] Alternatively stress tests could be applied to non-market, alternative assets.

investors do with the active managers they hire. This would enable the pension system to remain within the overall risk level that is deemed appropriate.

Alternatively, Viceira outlines that the benchmark could be made up of a portfolio of riskless assets which would generate the targeted replacement rate at the relevant investment horizon (i.e. a portfolio of inflation-indexed bonds with a duration that properly reflects the investment horizon of the population of plan participants). The performance of the fund would be measured against the performance of such a benchmark – the problem being that in practice there is a lack of such long-dated, indexed bonds, not only in developing but also some developed economies.

Supervisors could then work this analysis into their overall risk assessment via a 'traffic light' system. For example, a green light would indicate a pension fund with a portfolio structure aligned with the benchmark and a good risk management system.

Blake et al (2008) discuss a similar idea, again arguing that DC pensions should be structured 'from back to front', i.e. from desired outcomes to required inputs (via 'dynamic programming'), with the goal of delivering an adequate, targeted pension with a high degree of probability. DC funds should in effect be made more like DB – but with a targeted rather than a guaranteed benefit (as guarantees over the long-term are expensive), and the accumulation and decumulation phases of DC pensions should be linked via targeted annuities.[28] Currently fund managers have no 'target fund' to accumulate. The risk which fund managers take should be controlled not by quantitative investment rules, but rather through targeted annuitisation funds which they need to replicate (designed via some form of life-styling investment strategy during the accumulation phase). The role of regulators would be to set these target annuitisation funds as default options.

Impavido et al (2009) point out that: "a well functioning system of target annuitisation funds implies: (i) periodic estimations of the individuals' funded positions; (ii) a process for communicating to individuals the impact of market events on the probability of reaching their investment target; (iii) a process for communicating to individuals the impact of market events on the level of contributions that is expected to reach their investment target; and (iv) a close integration of the system of voluntary individual accounts, that many countries have also introduced, with the system of mandatory individual accounts." The pros and cons of such target annuitisation funds are outlined as follows:

[28] As described by Impavido et al (2009), target annuitisation funds are DC products with a target maturity (e.g., the retirement date) and where the construction of the investment portfolio is driven by a long-term financial target. A retirement benefit is targeted within a confidence interval. The optimal (strategic) asset allocation of these funds is not deterministic (i.e. it is not based on static rules), but derived from stochastic programming techniques that take into account the main risks faced by contributors during the accumulation phase, including labor income or human capital. The authors also point out that by having a long-term financial target, policymakers or regulators can better track the performance of pension fund managers throughout the entire accumulation phase of participants. However, this also implies that contributions may become "endogenous". That is, additional individual contribution rates may need to be made if it appears that the target will not be achieved. For some recent discussion of income risk of DC pension plans see Mantilla-Garcia et al. (2024).

Pros and Cons of Target Annuitisation Funds

Pros	Cons
They improve expected risk adjusted long-term performance by diversifying risk intertemporally (i.e. they reduce the investment risk borne by individuals).	They increase model risk borne by individuals.
They allow for full consideration of important background risks such as human capital and annuitisation risks.	The stochastic strategic asset allocation is complex and information intensive.
They do not create liabilities for asset managers during the accumulation phase since the long-term target (liability) is defined only in probabilistic terms.	They need supporting investment rules, sophisticated capital markets and general availability of risk management skills.
They are compatible with the physical separation of providers in the accumulation (asset managers) and decumulation phases (annuity providers).	They need adequate estimation of liabilities including good mortality tables.
They provide an adequate benchmark for monitoring long-term performance.	Overall contribution levels need to be endogenous.
They minimise a key concern associated with DC arrangements (volatility of replacement rates) while maximising a key benefit associated with DB arrangements (stability of replacement rates), albeit only in probabilistic terms.	Supervisors need to evaluate and monitor model risk.

SECTION 2: TECHNIQUES FOR QUANTITATIVE ASSESSMENT OF RISK[29]

The quantitative regulations discussed in the previous section may be basic regulatory requirements which can be made more 'risk-based' by introducing stress tests, etc. to evaluate whether these rules will continue to be met in future. The results of these tests can then be worked into an overall risk-based assessment. Alternatively, the quantitative regulations may themselves involve an element of risk analysis, which can likewise be included in a supervisor's risk-based approach.

This section will describe some techniques that supervisors can use in the quantitative assessment of risk (adding an element of risk analysis on top of basic quantitative rules). The key is to use these techniques to perform an overall risk assessment that recognises the interdependence of many risks. As stated, poor results from these quantitative tests imply higher levels of residual risk at the entity which is being analysed, which the supervisory authority would then factor into its overall risk analysis or risk score. Qualitative judgement is also required to assess the results of these tests effectively.

The tools which can be used include the following:

- comparison of valuation assumptions
- analysis of surplus
- roll-forward calculations
- duration analysis
- sensitivity testing
- deterministic stress testing
- stochastic stress testing
- value at risk (VaR) calculations.

This section will also discuss the principal objectives of each technique and the interrelationships among them. The techniques can provide different types of insights in the assessment of risk, so it is not unusual for a supervisory authority to use several in combination.

The table below summarises the contexts in which each of the techniques for quantitative assessment of risk might be applied.

[29] Worked examples of each of these techniques are also available as part of the IOPS Toolkit for Risk based Supervision.

Table 4: Application of Quantitative Risk Assessment Tools

Technique	DB Pension Plan	Insurer or Pension Entity	DC Pension Plan
Comparison of assumptions	X	X	..
Analysis of surplus	X	X	
Roll-forward calculations	X	X	
Duration analysis	X	X	X
Sensitivity testing	X	X	X
Deterministic stress testing	X	X	X
Stochastic stress testing	X	X	X
Value at risk	X	X	X

It should be noted that it may not be feasible or appropriate to apply the various quantitative techniques set out across all types of pension funds. The nature, size and complexity of the pension fund should be taken into account.

1. Descriptions of the Techniques

Comparison of valuation assumptions – As noted in Section 1 of this Module, assumptions regarding future experience must be made when valuing defined benefits and guarantees. The results of the valuations can sometimes be very sensitive to differences in the assumptions. If optimistic assumptions have been made, the risk that the assumptions will not be realised in the future is heightened, as is the likelihood that past earnings and the current financial position of the entity have been overstated. The valuation assumptions made for an entity can be compared to those made for current valuations of similar entities and for previous valuations of the same entity, and considered in relation to current environmental conditions and expectations. The objective of such comparisons is to identify inappropriate assumptions, which might have contributed to an unrealistically optimistic valuation and thus an increased risk of future financial difficulty.

Analysis of surplus –The surplus of a pension entity for a financial period[30] will depend on its actual experience during the period as well as - for defined benefit plans and defined contribution plans that provide guarantees - the valuation bases used at the ends of the current and previous periods. By comparing actual experience to previous assumptions and recalculating the valuation using both new assumptions and those used in the previous valuation, the surplus can be identified and quantified. Analysis of this information can provide insight on a range of issues, such as the factors that most affected past results (and therefore might also affect future results), the validity of past valuation assumptions, and the reasonableness of the current assumptions (which affects the likelihood that future financial results will be adverse). Effectively, the analysis compares actual experience to assumptions for all the major parameters. This provides a check on the valuation process itself (the total change in surplus should be approximately equal to all the components, with a small balancing item for minor unreconciled parameters). It also helps the actuary to judge how appropriate the assumptions are (the smaller the deviation of experience from assumptions, the more

[30] For some financial entities, including defined benefit pension plans, different terminology is sometimes used in referring to the financial results for a period, such as change in surplus. Accordingly, the analysis discussed here might also be referred to as a gain and loss analysis.

appropriate the assumptions), taking into account that there will be a strong random element involved for all parameters. However, trends over time will help the actuary to improve the assumptions setting process.

Roll-forward calculations – The financial position of a pension entity can be projected from a valuation date to future dates by using information produced by the valuation to roll-forward the values of the various balance sheet items. Roll-forward calculations can be used to roughly estimate the financial position of the entity under some types of scenarios of interest to the supervisor. Examples of such scenarios might include: at the next valuation date, if all assumptions are realised; at an inter-valuation date, using reported asset values and projected liabilities; and at the next valuation date, if equity markets decline by 20 percent and all other assumptions are realised. The results of the calculations can help in assessing the exposure of the entity to future adverse experience.

Duration analysis – The future cash flows of a pension entity can be projected, either as part of the valuation process or independent of it. Cash flows related to assets can be compared with those related to liabilities. The projected cash flows can be compared directly, period by period, to identify timing mismatches. The average duration of each of the respective cash flow streams can also be calculated and compared. Duration can be used to estimate the sensitivity of the present value of a cash flow stream to changes in interest rates (for example, if the duration of assets is 7.5, a one percent upward shift in the yield curve will reduce their value by roughly 7.5 percent). Pension entities use duration analysis as a tool in the asset-liability management process. The objectives of duration analysis in the context of the quantitative assessment of risk by supervisors are to identify entities that face mismatch risk and estimate their financial exposure—or, the exposure of participants in defined contribution plans—to changes in interest rates. This type of analysis is also known '*asset liability management'*.

Sensitivity testing – The sensitivity of valuation results to differences in assumptions can be quantified by recalculating the results using alternative assumptions. For example, results could be calculated using discount rates one percent higher and one percent lower than those assumed in the valuation. If the sensitivity to more than one assumption is to be tested, changes in the assumptions are usually tested one at a time to simplify the interpretation of results. The objective of sensitivity testing is to provide quantitative estimates of the extent to which the financial situation of a pension fund would be exposed to changes in key environmental factors. In the context of a defined contribution fund, sensitivity testing can, for example, be used to estimate the effect of changes in interest rates and equity values on the account values of participants.

Deterministic stress testing [31]– One recent innovation in risk-based supervision has been the application of "dynamic solvency testing" or stress tests. This is a forward-looking approach used to determine how robust the funding of the pension plan (or other financial institutions for that matter) is. The testing would consist of projecting forward the funding of the plan, both on a going concern and solvency basis, on various scenarios, including adverse scenarios. This could be done on a deterministic or stochastic basis.[32] Such analysis will indicate how robust the funding is in the face of adverse conditions and the additional funding that might be required under these circumstances. The supervisory agency can then compare projections with actual outcomes, as time goes by. This will enable them to identify plans that might be particularly vulnerable to feasible changes in the economic and social environment. This process could be used on a voluntary basis, with mandatory application be deferred until greater capacity is available to the pension industry. Deterministic stress testing involves calculating the financial position of a pension entity—or the financial situation of a participant—at either the current or a future valuation date on the basis of one or more defined adverse scenarios. Each scenario might vary the assumptions with respect to only

[31] Further details and examples of stress testing can be found in IOPS (2014), Stress Testing and Scenario Analysis of Pension Plans, IOPS Working Paper No. 19 and IOPS (2021), Supervision of solvency of occupational DB pension funds, Working Paper No. 35.

[32] Though it should be noted that stress test results are only one criterion for the scenario calculation.

one factor, such as interest rates, or vary several factors at once. The objective of deterministic stress testing is often to help assess the financial ability of an entity to withstand the effects of various risk scenarios, should they occur. In the context of a defined contribution pension plan, stress testing can be used to help assess the effects of various risk scenarios on the fund values and potential retirement incomes of the members and beneficiaries. However, it does not provide any information on the likelihood of such scenarios occurring.

Stochastic stress testing – Stochastic stress testing also involves calculating the current or future financial position of a pension entity, fund, or participant under various scenarios. However, it differs from deterministic stress testing in that the scenarios are not predefined. Instead, scenarios are computer-generated based on probability distributions for one or more important assumptions. Hundreds or even thousands of scenarios might be generated, with the financial results calculated under each. The distribution of the results can be examined to help assess how an entity's financial position—or the fund values or potential retirement income of a member or beneficiary, in the case of a defined contribution plan—would respond to a wide range of future conditions. It provides insight on the likely scenarios sufficiently adverse to create financial difficulty will occur.

Value at risk calculations – Value at risk (VaR) is a measure of market risk that relies on stochastic modelling techniques to measure aggregate risk exposures. VaR is the expected loss from adverse market movement with a specified probability (confidence interval of, say, 95 percent) over a particular period of time (say, one day). The 95% confidence interval means that, for every 1000 scenarios run, 26 can breach the maximum downside limit. If the modelling suggests that this level would be breached more often, the risk in the portfolio would have to be reduced. VaR can be used as a measure of the net market risk exposure of a defined benefit pension plan. It can also be used as a measure of the volatility risk to which members or beneficiaries of a defined contribution pension plan are exposed.

2. Interrelationships

Several of the techniques are based primarily on historical information that is often produced during the valuation process and included in actuarial reports or the notes to financial statements. These techniques include a comparison of valuation assumptions, sensitivity testing, analysis of sources of earnings, and roll-forward calculations. Duration analysis might also be performed routinely by the entity, either as part of the valuation process or in connection with its asset-liability management activities. If such information is not already routinely provided to the supervisor, it should not be particularly difficult or costly for entities to comply with requirements to do so.

However, except for the comparison of valuation assumptions, roll-forward calculations, and some simple sensitivity tests, all of the techniques involve calculations using detailed information about the assets and liabilities of the entities. Therefore, it is seldom practical for a supervisory authority to implement such techniques entirely on its own. The cooperation of the pension entities in carrying out the detailed calculations is needed as input for the supervisory analyses is thus essential.

Pension entities are not likely to be performing stress testing and calculating VaR as a routine part of the valuation process, although some might be doing so in connection with their risk management programs. Deterministic stress testing can be performed fairly easily in connection with the valuation process. However, both stochastic stress testing and VaR calculations require a considerable amount of detailed historical data as input to the calculations, along with a high level of technical expertise. Therefore, the practicality and costs of compliance would need to be carefully weighed when considering the application of these techniques.

Although a supervisory authority need not use all of these techniques in order to successfully perform the quantitative assessment of risk, each can make a contribution. In fact, having certain techniques in place can contribute to the effectiveness of others. Comparison of assumptions can provide context when reviewing analyses of sources of earnings, which are driven by variances between actual experience and previous assumptions and by changes in valuation assumptions. Comparison of assumptions also can help when considering which sensitivity tests might be useful. The results of sensitivity tests, duration analysis, and VaR calculations can help when designing the scenarios to be used in deterministic stress testing.

SECTION 3: INTEGRATING QUANTITATIVE TOOLS INTO RISK ASSESSMENT

Integrating Quantitative Tools

The sections above have outlined a number of risk factors and ways of measuring them. Module 4 of the IOPS Toolkit covers risk scoring in more detail, but these paragraphs will discuss how these risk measures can be used to provide risk profiles for supervised pension entities.

It is difficult to discuss these issues without some context in regard to the pension system in which the pension entities operate. It is essential that the quantitative assessment of risk focuses on the quantifiable risks that are most relevant to the pension entities being assessed, considering both the present environment and how it might evolve over time. Which are the most relevant risks depends on the nature of the pension plan.

There are a number of categories that need to be considered separately, namely:[33]

- defined benefit plans;
- defined contribution plans without guarantees;
- defined contribution plans with guarantees.

DB Plans

Factors such as the existing level of funding and future mortality rates, investment returns, inflation, and business viability affect DB pension plans. Hence, for occupational defined benefit pension plans, the key quantitative risk measures are generally the ***solvency and funded ratios***, the former generally on a wind-up or discontinuance basis, the latter on a going concern basis. If both are above 100% the risk to pension plan members would be considered to be minimal. If one or both were below 100% then risk scoring would need to assign a risk factor to the plan. Ideally, this should simply be the ratio itself, although if valuation bases were not standardised and there was some concern about the reliability and consistency of parameters, it might be appropriate to use bands instead (for example one unit if between 0.90 and 0.99, two if between 0.80 and 0.89, etc.). The direction of the solvency and funded ratios over time should also be taken into account- an increasing ratio would be a mitigant, while a reducing ratio a significant aggravating factor and would be scored accordingly. Ratios above 100%, but on a downward trajectory would also be risk factors, unless some explanation is forthcoming (for example surplus used to increase benefits).

Other tests, such as ***roll-forward, stress tests*** and so on, would be useful indicators and if they indicated satisfactory results would be a mitigant, for example for plans with funded ratios below 100%. It is not clear what a "satisfactory" result might be, but generally if stress tests showed increasing funded ratios over future years, even for somewhat negative scenarios, this would be satisfactory. Similarly, fully funded plans which

[33] Consideration of which parties bear various risks also need to be made. For example, shortfalls in DB plans are often borne by employers, but members and beneficiaries may also have to raise contributions or see their benefits reduced – whilst the risks arising from poor investment results under a DC plan are largely born members and beneficiaries, unless an insurance company or other parties provides a guarantee. The relative importance of various risks might also differ in accordance with environmental and market (systemic) factors. For example, longevity risk might be more significant in a developing country with rapidly improving mortality, whilst inflation rates and the liquidity and volatility of investment markets can vary significantly from one country to another—and at different times in a particular country, creating different risk-management priorities for pension funds and plans and their supervisors.

showed future funded ratios of less than 100% only in the most extreme scenarios would receive a good score. To some extent the fact that plans are performing such tests, whatever their outcome is a positive attribute of good plan governance and should be recognised as such. Analysis of surplus would also give rise to a good risk score if residuals were small and the analysis indicates that assumptions tend to be somewhat conservative (more gains than losses).

Another form of quantitative risk assessment which can be used for occupational DB plans is ***Asset Liability Management*** (ALM) – as discussed previously in relation to duration analysis. This is based on the idea of 'immunisation', whereby assets and liabilities of the same duration are held to reduce interest rate risk. Trying to apply ALM to DB occupational pension plans faces numerous challenges (due to the very long-term nature of the liabilities, their frequently being indexed to wages, the potential increase in costs from investing in all bond portfolios, etc.).[34] Therefore, while strict immunisation is probably not applicable to the vast majority of defined benefit pension plans, asset liability management is a well established technique for such pension plans. ALM seeks to minimise and manage the asset related risks as a function of the liabilities and to find natural hedges, i.e. ways in which the external environment (for example a change in interest rates) has a comparable impact on assets and liabilities, thereby protecting the surplus (or ensuring the unfunded liability does not get worse due to unfavourable market movements).

A strict form of ALM can be applied to closed DB plans consisting entirely of pensioners. For open funds, ALM can be applied to estimated cash flows.[35] Investments do not need to be confined to fixed income assets.[36] More recently there has been an interest in "liability driven investment" (LDI) – assuming a pension fund operates more like an endowment fund with more of less fixed cash flows which can be immunised.

Pension supervisory authorities' interest in ALM is in regard to overall risk management. A well-executed program of ALM will give the supervisor greater confidence in the risk management and control function and will reduce the risk of a well funded plan losing that status (though the pension supervisors must also be aware of the pitfalls of ALM and ensure that it does not provide a false sense of security for the trustees).

[34] See for example Cohen (1990).

[35] A common method would be to project cash flows, both for assets and liabilities, on a variety of assumptions, and run simulations, either on a deterministic or stochastic basis, so as to minimise asset risks (mostly market risks, i.e. fluctuations in rates of interest and hence increases and decreases in bond prices and market movements for equities, taking into account correlations between such market movements) and chose a parameter to manage, by varying the asset mix. The parameter could be the future contributions, the future expense charge on an accounting basis (these are often different) or funded ratios. These models can be quite complex and of course highly dependent on assumptions, correlations, etc. as well as econometric models (what is the interrelationship between interest rates, economic activity, salary increase, termination behaviour, retirement behaviour, etc.).

[36] In fact, some argue that equity investments such as shares and property tend to increase in value in line with economic activity, albeit with much volatility, so that in the long run they are better matched to final salary liabilities than fixed income securities. Others argue that firms should be making money by taking risks in their core business and not by putting pension funds at risk and so should only invest in fixed income securities. To some extent this mirrors the debate between "actuaries" and "financial economists", but these paragraphs cannot do justice to that debate. By and large, pension funds are invested in a balance portfolio with a risk-adjusted rate of return maximisation target, notwithstanding this controversy.

DC Plans without Guarantees

Although the participants of DC plans also face a full range of risks, the obligations of the plans themselves are typically limited to the investment of contributions made by and on behalf of the members and beneficiaries. Therefore, the greatest threats to the interests of the members and beneficiaries of defined contribution plans are low real investment returns, volatile investment returns, excessive costs and fees and unsafe custody of assets.

For **occupational defined contribution pension plans** where members have investment choices, there are few quantitative measures the pension supervisory authority could employ. As discussed, ***VaR*** measures may be used but are controversial, and '***replacement rate-based' targets*** are still under development. The pension supervisory authority would want to ensure that investment returns are properly calculated and expense charges are minimised. There are a number of qualitative tests that should be applied, and these are discussed below.

Occupational defined contribution plans where one fund applies to all members can pose a systemic risk as sometimes market rates of interest are not allocated and "surpluses" (or worse "deficits") build up. The pension supervisory authority should ensure that all members are treated equitably and that assets are marked to market and investment earnings, minus reasonable expenses, are allocated on a market basis (this could include negative rates of return). If this is not the case, then these funds should be scored negatively for risk. If pensions are paid from the fund (which is sometime the case with this type of fund, less often the case with "member choice" funds), then pensions in payment are treated as DB and can be assessed for risk as described above. In fact, for pensioner only funds, such measures as duration and asset-liability matching can be applied with more rigour than is the case for defined benefit pension plans with members in the accumulation phase as well, as there is considerably less doubt about future benefits to be paid.

Individual accounts style DC plans (of the "Chilean" type) are a much greater challenge when it comes to quantitative risk assessment. If these systems have no guarantees, then effectively the pension accumulation funds are simply mutual fund corporations and run very little financial risk (although they would run operational and other non-financial risk), which is effectively passed on to contributors. The supervisory authority's role would then be to ensure transparency, efficient and low-cost operation (perhaps by way of maximum regulated fees, as in the United Kingdom's "second pensions", but this often has unintended and deleterious side-effects) and adequate communication. Again, VaR measures could be used but are controversial, or replacement rate targets developed.

Example: Chile[37]

One IOPS Member that has been exploring the possibility of stress testing pension funds against a benefit target is the Superintendence (Superintendencia) in Chile.

The supervisory authority has established that the relevant sources of risk faced by members of DC pension systems include:

- contribution-density risk or the risk of becoming unemployed;
- the investment risk (investment of pension funds);
- the risk of annuitization or re-investment when the final balance of the member's individual account is transformed on retirement into the value of the pension; and
- longevity risk.

Bearing in mind the long-term nature of the pension funds and the aforementioned risks associated with the pension, the risks must be measured and evaluated from the point of view of the member´s life cycle. If this is defined as a target variable (a variable that best represents the member´s position on retirement), the replacement rate, measured as the ratio between the value of the pension at the moment of retirement and a relevant measurement of wage, five relevant factors can be identified that will affect its expected value and volatility:

1. the accumulated return of the fund's investments (accumulated balance in the individual funding account at the moment of retirement);
2. the accumulated volatility of the chosen investment strategy;
3. the volatility associated with the contributions (failure to contribute consistently throughout the lifecycle);
4. the cost associated with one unit of pension, or necessary capital (annuitization or re-investment risk); and
5. longevity risks which affect the value of the pension received.

[37] IOPS (2014), Stress Testing and Scenario Analysis of Pension Plans, IOPS Working Paper No. 19.

Example: Australia[38]

The Australian Prudential Regulation Authority (APRA) has developed a heatmap that uses a graduating colour scheme to provide clear and simple insights into MySuper products across three areas: investment returns, fees and costs, and sustainability of member outcomes.

The Heatmap metrics are based on data reported to APRA by registrable superannuation entity (RSE) licensees and benchmark data from index providers. The metrics are:

• the annual performance test results for MySuper (from 2021) and Trustee Directed products (from 2023);

- The annual performance test sets a legislated performance benchmark that incorporates investment performance and administration fees. To pass the test, the product's performance measure for the relevant lookback period must equal or exceed -0.50% p.a.

- MySuper products that failed the test for the latest lookback period are labelled "Fail" in the relevant column of the Heatmap. Those products that also failed for the lookback period of the previous year are additionally identified as "Fail – second consecutive time".

• investment return metrics over three, five and eight-year time horizons for MySuper products, and for each lifecycle stage (where relevant);

• administration and total fees and costs metrics covering representative member account balances of $10,000, $25,000, $50,000, $100,000 and $250,000; and

• sustainability of member outcomes metrics, including member account growth and net cash flow measures that provide some insight into the ability for an RSE licensee to continue to provide appropriate outcomes to members.

The Heatmap metrics apply to all products, including lifecycle products. Further details regarding the methodology can be found here: Methodology paper - MySuper Heatmap (apra.gov.au) and Methodology paper – Choice Heatmap (apra.gov.au)

DC Plans with Guarantees

For most - if not all - of these individual account, DC systems various types of guarantees are part and parcel of the system. Guarantees can be related to rates of return, or minimum defined benefits. Minimum defined benefits will often be provided by way of subsidies from the state, so pension supervisory authorities may not have to concern themselves with such guarantees. If they do need to supervise such hybrid systems, then they need to be able to rely on defined benefit type supervision and in fact be aware of the "option premium" inherent in these types of plans. This can be very complex. They may have to supervise the conversion of accumulation into pension or the parameters for "scheduled draw downs", or "programmed withdrawals". Sometimes the pension supervisory authority actually provides such factors (in some cases they can be erroneous, as these are tricky actuarial calculations). All such actions require some degree of actuarial input, and so the type of risk analysis will be very similar to that used for defined benefit plans. If pension supervisory authorities are providing actuarial tables and other factors themselves, they should avail

[38] https://www.apra.gov.au/superannuation-heatmaps

themselves of the best actuarial advice available, to avoid incorrect calculations and hence risk to the authority itself.

Of particular concern is the risk posed by performance guarantees. Some are of the *absolute* variety (for example a guaranteed rate of 3 or 4%), which in theory could be hedged in economies with well-developed financial derivatives markets. Others are *relative* (e.g. at least 70% of the return of all funds over a particular period). This is an unhedgeable risk and can be difficult to measure and score for risk, although a simplified approach is suggested below. It causes all pension accumulation funds to clone each others' asset mix, which reduces choice and is not really desirable, but does reduce the risk of the guarantee going "in the money" for any particular fund. Pension supervisory authorities could therefore attempt to measure the risk posed by such guarantees by assessing the likelihood of guarantees going "into the money" and the likely magnitude of the shortfalls. This is not easy with either type of guarantee. Stochastic methods could be used, but apart from the fact that they are complex and probably beyond the capacity of both practitioners and supervisors in many markets, their reliability for this particular purpose at least is suspect. These methods treat financial parameters such as interest rates and stock market returns as random variables. This may be true to some extent, but such things as interest rates are subject to secular trends as well as fluctuations around the norm. They are also prone to "black swan events" – for many years it was thought that interest rates as low as those experienced in the 1950s (in say the United Kingdom, where yields on "Consols", which are perpetual bonds of the government reached about 2%) would never be seen again. In Europe, North America and Japan at least interest rates approximating zero have now become common-place and interest rate guarantees which were thought to be so low as to never come into effect have caused extensive damage, including insolvency of financial institutions (and have had a significant impact on the viability of pension plans).

For *relative guarantees* (which often track interest rates over extended periods, as long as 5 years sometimes, and so the rolling averages are fairly predictable, the upcoming year only adding 20% to the total) the pension supervisor can track the potential for each particular fund to fall foul of the guarantee by monitoring how its asset mix differs from the average and applying volatility factors for the various asset classes.

Example Quantitative Assessment Relative Guarantee

For example, if a fund has an equity asset mix 10% above the average and the volatility of this asset class was considered to be 30% (say twice the standard deviation of 15%), then there would be a potential for the rate of return for this fund to be 3% (0.1 * 30%) below the average. This could be repeated for all other assets classes. Correlations could be taken into account. If the average were taken over more than a year, past performance would also be taken into account. This would be a reasonably simple algorithm to provide risk measures for this kind of guarantee, which appears to be quite common in these types of systems. This is a more direct approach that targets the actual risk, rather than being based for example on Basel I or II type factors which are related more to credit and market risks of the assets and not to the guarantee itself. Similarly, such an approach would be a lot simpler and more direct than VaR, which again targets the individual volatility of funds and not their relative performance. This is illustrated by a simple example. Taking the following estimated returns and volatility for the asset classes, and adding to them the hypothetical asset mix for all funds, and then individual mixes for two individual funds (Funds A and B), we can find the variations (i.e. the difference between the average mix and that for each fund) and hence the weighted average of the volatility (standard deviation) for these variations for each fund (this is done by squaring the standard deviations weighted by the variations and taking the square root of the sum; a correlation term would then be added by taking into account the covariance matrix).

	Return	Volatility
Cash	4.0%	2.0%
Bonds	5.5%	4.5%
Equity	7.5%	15.0%
Property	6.0%	10.0%

Correlation Matrix				
	Cash	**Bonds**	**Equity**	**Property**
Cash	100.0%			
Bonds	20.0%	100.0%		
Equity	0.0%	0.0%	100.0%	
Property	0.0%	0.0%	50.0%	100.0%

			Asset mix			Variation	
	Return	**Volatility**	**All**	**Fund A**	**Fund B**	**Fund A**	**Fund B**
Cash	4.0%	2.0%	5%	3%	7%	-2%	2%
Bonds	5.5%	4.5%	40%	35%	44%	-5%	4%
Equity	7.5%	15.0%	40%	48%	38%	8%	-2%
Property	6.0%	10.0%	15%	14%	11%	-1%	-4%

The average rate of return on the "all funds" portfolio is 6.3%. Suppose the guarantee is that fund rates should be at least 70% of the return for all funds over a year. This means that the maximum variation before the guarantee kicks in is 1.9% (rounded to one decimal – all other figures are also rounded to one decimal, which accounts for the slight differences). For Fund A the weighted standard deviation is 1.2%. At the 97.5% level, assuming a normal distribution a variation of twice the standard deviation, or 2.3% could be expected, which exceeds 1.9%. The corresponding figures for Fund B (once and twice standard deviation) are 0.6 and 1.3% respectively, the latter figure being less than 1.9%. Therefore, Fund A bears about twice the risk of falling foul of the guarantee, and is likely to do so at least once in twenty years[1] or even more frequently, while Fund B is unlikely to do so. Fund A should maintain at least 0.4% of its total assets (2.3% minus 1.9%) to guard against this contingency, while Fund B's capital requirements would be minimal. This is a rather simplistic example, but could be made more realistic (for example by using a more sophisticated approach to cross correlations and "fatter tailed" distributions rather than the normal distribution). The risk measure could relate to the amount of capital the fund retains for the purpose of the guarantee in relation to the required capital calculated in the manner described here.

Notes:

[1] Since the distribution is symmetrical, 95% of the results in the middle would fall within two standard deviations, in other words 19 years out of 20. The 97.5% figure refers to the half of the results which are unfavourable that fall outside the twice standard deviation range – we have little interest in the other half which represents exceptionally good results

For *absolute guarantees*, VaR or CTE could be used, but over a period appropriate to the measurement period of the guarantee, rather than daily, could be used to rank funds as to which are more at risk. However, the real risks for these kinds of guarantees are systemic. In other words, if there is a permanent downward shift of interest rates to below the level of the guarantee, all funds would become insolvent and no amount of capital would be adequate to stop the bankruptcy of the whole system, it could merely delay it. This would probably mean nationalisation of the system and/or government subsidies or changes to the guarantee (it is not unknown for such guarantees to be tinkered with, thereby bringing into question the meaning of the word "guarantee").

Example: Quantitative Assessment Absolute Guarantee

It is difficult to provide simple algorithms for this kind of guarantee, but as a first approximation it could be treated in much the same way as the relative guarantee above. Funds A and B would be far too high risk for such a guarantee, so we would have to assume something like the fund shown below:

	Asset mix	Return	Volatility
Cash	20%	4.0%	2.0%
Bonds	70%	5.5%	4.5%
Equity	10%	7.5%	15.0%
Property	0%	6.0%	10.0%
Total	100%	5.4%	3.6%

Even for this conservative asset mix, with a substantially lower long-term rate of return than Funds A or B, negative rates of return are possible, as twice the standard deviation exceeds the average rate of return. If a 3% guarantee were in effect, then we could expect a return as low as -1.8% (5.4% minus 7.2%) one year in twenty, in the very simple normal distribution universe, or almost 5% below the guarantee. In fact, we would expect to see the guarantee invoked fairly frequently, as it is less than one standard deviation from the average rate of return. At least 5% capital would be expected and risk measures related to actual capital could be developed. It should be emphasised that this is a very simplistic approach and stochastic modelling, as described above, would be more appropriate for this type of risk.

Quantitative tools for measuring non-financial risks

Non-financial risk encompasses those risks that are not covered by traditional financial risk management. Such risks include operational risk, market conduct risk, IT risk, legal and regulatory risk, contagion and related party risk and governance risk[39].

While such factors are very difficult to judge and equally difficult to score numerically, they are of great utility to the pension supervisory authority, as they tend to be "leading" indicators, as compared to the numerical factors, which tend to be "lagging" (although not always, stress testing is a leading indicator).

[39] See Module 3 for further details of risk factors in funds

Sources of information include the reliability of the filing process itself (always on time, occasionally in arrears, persistency in arrears), as well as on-site reviews, although as noted it is probably impossible to visit all pension funds where there are more than a handful.[40] Other sources, such as self-assessment questionnaires and interrogatories, complaints to the pension fund or supervisory authority would also provide useful information.

Examples of activities and analysis undertaken to assess behaviour and culture:

- Issuing guidance and regulations to supervised entities and monitoring their compliance via ongoing supervision activities;
- On site supervision activities including meetings with board and management where interactions could be observed and assessed;
- Observations made via other interactions with the pension fund (e.g. the pension fund's responsiveness to requests from the supervisory authority);
- Review of board papers and minutes to assess decision making including the processes involved, the matters considered and to what extent any conflicts are identified, managed or avoided to ensure decisions are focused on the interests of the members and beneficiaries;
- Monitoring complaints and market sentiment. This includes receiving reports on complaints from members and beneficiaries to pension funds as well as monitoring the outcomes of complaints and the adequacy of the processes within pension funds to resolve complaints;
- Consideration of the quality of management including when undertaking fit and proper due diligence;
- Questionnaires aimed at identifying corporate values within pension funds, how such values are communicated and whether responsibility and communication are well defined within the supervised entity;
- Review of audit reports (both internal and external) including how responsive the pension fund is to audit findings;
- Review of board declarations including assessing to what extent the statements made align with the supervisor's own knowledge of the entity. For example, if the board declaration states that there have been no material breaches of obligations but the supervisor is aware of such breaches having occurred, there may be cause to question the veracity of the declaration.

Source: IOPS, From RBS Learning Project Supplementary Questionnaire results.

[40] On site reviews referred to in the IOPS Toolkit for Risk-based Supervision are reviews which take place physically at the premises of the supervised entity.

Examples of activities and analysis undertaken to assess member outcomes and the quality of services provided to members:

- Monitoring complaints, including assessing how complaints are handled after the end of year account reports are issued;
- Having a mechanism for members to complain directly to the supervisory authority;
- Assessing board composition though with a focus on ensuring members were adequately represented and/or to identify potential conflicts of interest;
- Review of disclosures and communications to members including monitoring web pages and other material provided to Members such as the annual income statements;
- Setting and monitoring minimum service expectations. This includes checking whether deadlines have been met for the provision of pension benefits;
- Undertaking and publishing comparative data analysis relating to pension funds[41,42];
- Monitoring investment activities and performance, in some instances daily, and examining returns and costs reported via quarterly and annual data submissions;
- Surveys and questionnaires of pension fund members and staff to assess quality of services and the working environment;
- Tracking pension benefits including suspended, deferred or unclaimed benefits via data analysis;
- Thematic inspections (either on site or off site) on topics such as record keeping; claims, sales agent activities and customer service; and
- Engagement meetings with investment and risk managers, actuaries and auditors.

Source: IOPS, From RBS Learning Project Supplementary Questionnaire results.

It is important to recognise that not all relevant risks lend themselves easily to quantitative assessment. For example, it is very difficult to assess the potential financial effects of mismanagement of a pension fund by those responsible for its governance, particularly with respect to estimating the likelihood that mismanagement will occur. Therefore, while quantitative analysis may support the risk assessment, in general, the overall assessment of risk will be based on a combination of both quantitative and qualitative assessments of relevant risks.

Supervisory authorities – particularly those rolling out a new risk-based framework – may be in danger of over-complicating and making their risk-based frameworks too rigid if they try to rely too heavily on quantitative indicators alone. Additionally, given that risk assessments will retain some subjectivity, it is important that a system be in place to ensure a reasonable degree of consistency between analysts (see Module 4 of the IOPS Toolkit).

[41] In Lithuania, this includes sharing indicators of pension funds and tax rates.

[42] In Colombia, the SFC has developed a supervision tool called "SuPension" where people can find information on the General Pension System -GPS- (graphs - indicators). This tool contributes to the monitoring of pension fund administrators, and allows users to compare the management quality and provision of services of the different administrators.

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