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Stress Testing and Scenario Analysis of Pension Plans

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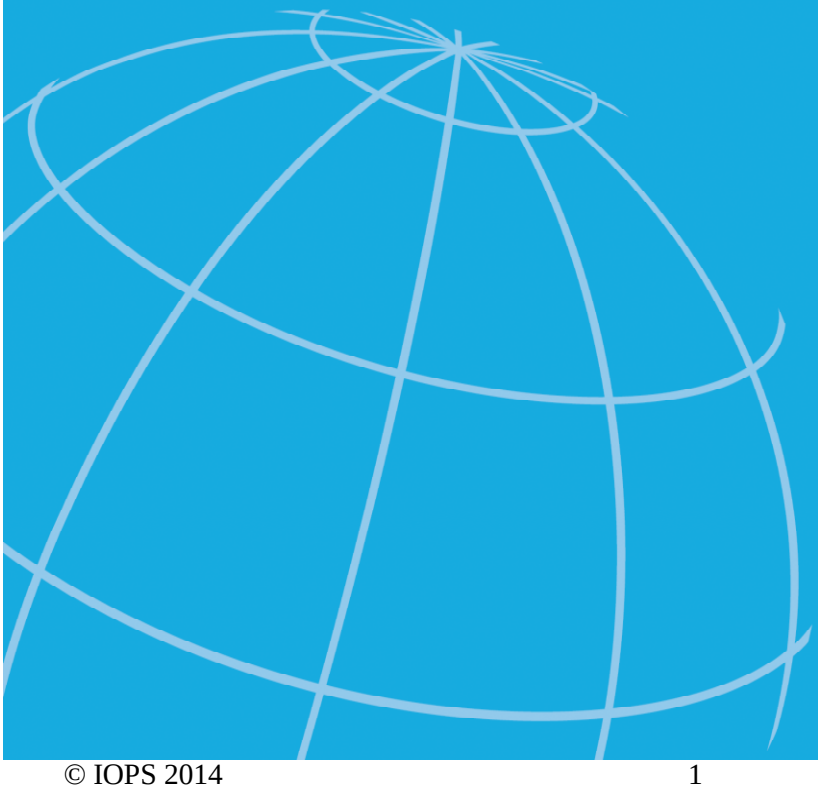

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INTERNATIONAL ORGANISATION OF PENSION SUPERVISORS

STRESS TESTING AND SCENARIO ANALYSIS OF PENSION PLANS

ABSTRACT

Stress testing is a useful and increasingly popular method of analysing the resilience of financial systems to adverse events. It has only recently been introduced to the pensions sector in some countries as well. This paper presents the results from a survey of stress testing practices among IOPS member countries and provides some reflections on whether and how stress testing could be applied in DC plans. In addition to the technical aspects of stress testing, the paper dwells on the governance requirements for stress testing, drawing some conclusions and lessons for pension supervisors as they introduce and develop their own techniques.

Keywords: Stress testing, risk management, supervision, defined benefit pensions, defined contribution pensions.

JEL codes: G23, G32.

TABLE OF CONTENTS

STRESS TESTING AND SCENARIO ANALYSIS OF PENSION PLANS 5

I. Introduction 5
II. Definitions of stress testing 6
Sensitivity testing 6
Scenario analysis 7
III. Considerations for stress tests in a DC environment 8
IV. Different methods of stress testing 11
Historical vs. hypothetical 11
Deterministic vs. stochastic 11
Reverse stress testing 12
V. Experience with stress testing pension funds 12
Defined benefit pensions 14
Hybrid pension plans 17
Defined contribution pensions 17
Governance and supervisory requirements for stress testing 19
VI. Conclusions – how to improve pension stress tests 21

REFERENCES 23

ANNEX 1: USE OF STRESS TESTS FOR PENSIONS IN IOPS MEMBER JURISDICTIONS 25

ANNEX 2: EXAMPLES OF STRESS TESTS IN IOPS MEMBER JURISDICTIONS 37

Chile 37
Czech Republic 40
Germany 44
Israel 48
Norway 51

STRESS TESTING AND SCENARIO ANALYSIS OF PENSION PLANS[1]

I. Introduction

Stress testing is a useful and increasingly popular, yet sometimes misunderstood, method of analysing the resilience of financial systems to adverse events. It involves testing beyond normal operational capacity, often to breaking point, and looking at the extent of potential large portfolio losses and the possible scenarios in which these losses can occur.

In its *Principles for Sound Stress Testing Practices and Supervision* (BIS, 2009), the Bank of International Settlements highlights that stress testing is a tool which supplements other risk management measures, and plays a particularly important role in informing and setting of an institution's risk tolerance and in facilitating the development of risk mitigation or contingency plans across a range of stressed conditions.

As the IMF (2012) has pointed out, the recent financial crisis drew unprecedented attention to the stress testing of financial institutions. On one hand, stress tests were criticized for having missed many of the vulnerabilities that led to the crisis. On the other hand, they were given a new role as crisis management tools to guide bank recapitalization and help restore confidence. This spurred an intense debate on the models, underlying assumptions, and uses of stress tests.[2]

Stress tests are used widely in the banking and insurance sectors – both by the financial institutions themselves, and by the supervisory authorities which oversee them. For example, stress tests are central to the Basel II and Solvency II supervisory frameworks for international banks and EU insurance companies, respectively. They are also used in the International Monetary Fund (IMF) Financial Sector Assessment Programmes (FSAPs),[3] and more frequently in financial stability reports worldwide.

Stress testing has only recently been introduced to the pensions sector in some countries. Practices also vary depending on the type of pension plan supervised (defined benefit – DB, defined contribution –

[1] At the 2010 Annual General Meeting, IOPS Members voted to undertake work on stress testing for defined contribution (DC) pension plans with the project to be launched in 2012. The Mexican delegation kindly agreed to lead the project, with the assistance of Australia. The paper benefited from valuable comments provided by the IOPS Members, and from the IOPS Referee (Mr Ross Jones).

[2] For example, detailed papers and presentations on the topic can be found via the conference proceedings of a series of IMF expert forums held on 'Advanced Techniques on Stress Testing: Application for Supervisors'

http://www.imf.org/external/np/seminars/eng/2006/stress/index.htm

http://www.imf.org/external/np/mcm/financialstability/conf/2ndexpa.pdf

[3] See Tomas Balino (2006) that outlines how stress tests for both banking and insurance are increasingly used in FSAPs and have moved from single factor analysis to looking at more complex issues, such as macroeconomic scenario analysis and interbank contagion, and include non-bank financial institutions. Risks assessed in the tests include credit risk, market risk (interest rate and exchange rate), liquidity risk, and contagion/operational risk.

DC, or hybrid). There are few experiences of stress testing in DC plans. This paper presents the results from a survey of stress testing practices among IOPS member countries and provides some reflections on whether and how stress testing could be applied in DC plans. In addition to the technical aspects of stress testing, the paper dwells on the governance requirements for stress testing, drawing some conclusions and lessons for pension supervisors as they introduce and develop their own techniques.

The paper is structured as follows. After this introduction, section II presents various concepts and definitions of stress testing. Section III offers a forward-looking assessment of how stress testing could be developed in a DC context. Section IV discusses different methods of stress testing. Section V contains the experience of stress testing performed in DB, hybrid and DC framework. It also examines the various preconditions – including governance requirements – that should surround stress testing. The last section provides some tentative conclusions on how to improve stress testing and makes some recommendations to supervisors. The paper contains two annexes. Annex 1 summarises the current scope of stress test usage amongst the IOPS members, and Annex 2 provides detailed stress-test case studies from several countries.

II. Definitions of stress testing

The term "stress test" can be confusing as it is used to cover a broad range of modelling techniques. It can also be used to mean several different types of tests relating to pensions.

Sensitivity testing

Sensitivity testing is a process that aims to determine how changes to a single risk factor (parameter) will impact the institution or portfolio. This is the most basic level of stress test, where a single parameter is tested, often without relating the shock to the wider context of an underlying event or real world outcome. Such tests are typically conducted over a short time horizon (i.e. an instantaneous shock). An example of such a test might be assessing the impact of a 200 bps shift in interest rates on a portfolio.

The main benefit of these tests is that they can provide a fast initial assessment of portfolio sensitivity to a given risk factor and identify certain risk concentrations. They require limited resources and can be used as a simple technique for assessing the impact of a change in risks when a quick response or when more frequent results are needed. They are most appropriate in situations where fluctuations in portfolio value depend primarily on a single source of risk. While sensitivity analysis focuses on testing a single factor, such tests can be performed in a correlated manner, accounting for the expected co-movements between different factors (Ruban and Melas, 2010).

The results of a sensitivity analysis are easy to communicate to senior decision makers and provide an intuitive link between changes in risk parameters and outcomes. This type of test may to some extent be useful for trustees in their decision making. For example, they may test what would happen to asset values should the biggest bank fail, in order to test risk concentrations. It may lead them to find that they are not appropriately diversified, and hence change their investment strategy. To some extent, they can be used by supervisors for the same purpose – but the question then is to what end (i.e. what does the supervisory authority then do with the information)?

There might be sometimes confusion around how stress tests relate to risk measures – such as volatility, value-at-risk (VaR), or expected shortfall. These are summary statistics of the forecast return or solvency distribution in a stochastic model. While these statistics help evaluate the likelihood and size of potential losses, and identify the positions that contribute most to portfolio risk, they do not reveal how the losses might occur. Stress tests complement risk forecasts by attempting to answer questions such as: "If oil prices rise by 20%, how much will the value of my portfolio change?". The key advantage of stress tests is that they link a loss to a specific event, which can provide valuable information to risk managers

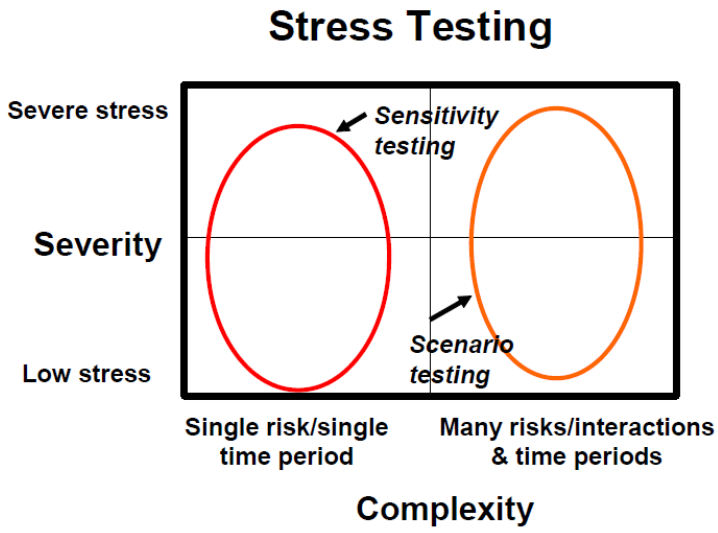
and supervisors beyond a summary statistic of the loss distribution. By enhancing our understanding of portfolio losses, stress tests can be valuable at all stages of the investment process, including portfolio construction, limit setting, and hedging (Ruban and Melas, 2010).

Scenario analysis

Scenario analysis studies the effect of a simultaneous move in a group of risk factors, analysing a portfolio's response to a complete scenario. Scenario testing uses a hypothetical future state of the world to define changes in risk factors affecting an institution's operations. This will normally involve changes in a number or risk factors, as well as ripple effects that are other impacts that follow logically from these changes and related management and regulatory action.

Scenarios can be designed to encompass both movements in the levels of market variables (prices) and changes in the underlying relationships between different assets or markets (volatilities and correlations). Such testing provides a more complete assessment of portfolio risk. Scenario testing is typically conducted over the time horizon appropriate for the business risks being tested (Ruban and Melas, 2010).

Figure 1. Sensitivity testing vs. scenario analysis



Source: OSFI Canada (OFSI, 2009).

For scenario analysis, the additional issue of correlations needs to be considered. As the IAIS (2003) points out, risks are seldom totally independent or totally related, and future correlations should not be understated (as evidence has shown that in adverse situations, previously low levels of correlations may dramatically increase). A degree of prudence and pragmatism is required to determine the extent of dependencies.

III. Considerations for stress tests in a DC environment

Stress testing in a DC environment raises a few challenges. The first question that arises is "what to stress test a DC pension fund against". Before trying to tackle this question, supervisors should assess the purpose and importance of stress testing in a DC environment.

1. Purpose and importance of stress testing in a DC environment

The purpose of stress testing in a DC environment may seem quite straightforward. Because members bear the investment risk, the purpose of stress testing would be to better manage investment risk. Trustees or pension providers should realise the importance of delivering outcomes in line with the reasonable expectations of members.

Even though it might not be a specific legal requirement, DC pension providers should develop a risk management strategy where stress testing plays an important role. The stress tests developed should be developed based on difficult and realistic conditions and should address the multi-faceted nature of risks in the DC environment (investment limits, asset classes, volatility, liquidity, etc.) and how these risks affect the interests of members.

However, the IMF (2012) also underscores that the success of stress tests cannot be reduced to the choice of a few parameters but should be seen in a broader context. To be sure, certain aspects of stress test design are crucial. The choice of risk scenarios, in terms of both the coverage of all relevant risk factors and their severity; the design of the tests so that they cover all important transmission channels and include realistic assumptions about buffers; and the choice of hurdle rates are key for the reliability of stress test results.

It may be the case, however, that trustees find it difficult to make informed decisions about which outcomes are detrimental to pension fund members and beneficiaries, and tend to attach more weight to scenarios which most closely resemble the current situation, making it difficult to be truly prepared for extreme scenarios. Turning abstract numbers into a concrete plan in order to be prepared requires training and dedication.[4] A final concern regarding stress testing in the pensions sector is making sure that the temporal dimension of pensions' management is maintained. Stress testing very much focuses attention on short-term risks, while pension fund investment decisions should be taken with a long-term horizon in mind.

2. What to stress a DC pension fund against?

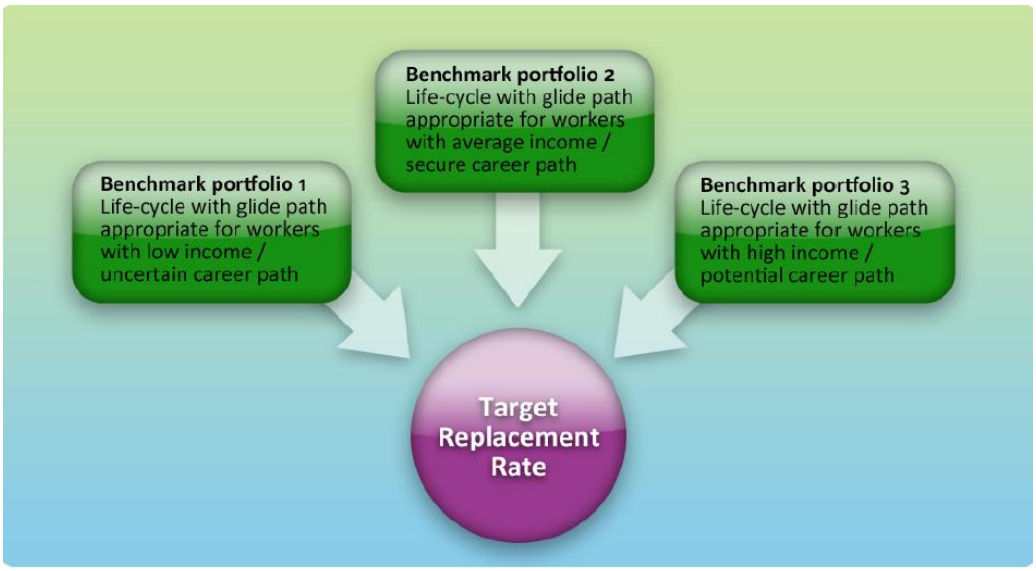
Stress testing DC pension funds raises the question of what is the objective of the test, and what is being tested for. How a portfolio will react to certain (extreme) conditions is only partially useful information when it comes to pensions, as the issue is not so much "*what will the size of the accumulated pension portfolio be*" as "*will this deliver an adequate retirement income*". How to apply stress tests to pure DC pension plans is challenging, as by definition DC pension plans do not have any promised benefit or outcome goal. Indeed, this may be why stress testing is still a relatively unknown and little used concept within the DC pension world.

The probability of not meeting an outcome therefore has to be "artificially" introduced if such testing is to be more developed as a DC concept. The challenge is deciding what outcome should be used to stress test against. Indirectly, what these tests are really trying to examine is the impact of adverse events on the

[4] *Training for the Stress Test*, Investment Beliefs.org, 13/3/2011 http://investmentbeliefs.org/2011/03/training-for-the-stress-test/

level of pension income individuals will receive, as this is what the accumulated pension pot is ultimately used to purchase. Academic studies have proposed directly targeting retirement income (via a replacement rate).[5] Stress tests could then be done on how likely it is that this target retirement income will be delivered in adverse circumstances (rather than indirectly stress testing the size of the pension pot accumulated).[6]

Figure 2. Target-based risk measures for DC pension funds testing



Source: IOPS Toolkit Risk-based Supervision, www.iopstoolkit.org.

[5] The replacement rate of a pension is the percentage of pre-retirement income which the pension provides. For example, if an individual's pre-retirement income was $10,000 and their pension provides them with $7,000 a year, the replacement rate is 70%.

[6] For a discussion of such replacement rate targets, see IOPS Toolkit for Risk-based Supervision, Module 2, *Quantitative Assessment of Risk*, www.iopstoolkit.org

Box 1. Stress testing DC pensions – Chile

One IOPS Member which is currently 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 life-cycle);
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.

One of the key challenges of developing a stress testing methodology based on target benefits is that one also needs to simulate the benefit levels from other income sources (for instance, the public pension system) and their degree of security. This should be done before one can determine a suitable risk scenario for the DC part. Furthermore, in voluntary pension systems or mandatory systems with high levels of informality, the contribution density will affect dramatically the target benefit. Yet, it is not possible to know a priori what the contribution density of a person will be, and hence the stress test may provide an inadequate measure of the true benefit risk faced by the member.

Despite these shortcomings, target benefit and target return stress testing can be useful tools, in particular as part of the review of investment strategies. The topic of outcome-based targets and stress testing for DC pension funds will be considered in more depth by the IOPS in a forthcoming project.

IV. Different methods of stress testing

Historical vs. hypothetical

The events being tested under either sensitivity testing or scenario analysis can be based on *historical scenarios or hypothetical* (usually extreme) events.

Historical scenarios are based on events in the past, for example the emerging market debt and currency crises of the late 1990s. They are fully articulated and involve little judgment in implementation (though with exponentially weighted stress tests, historical periods more similar to the defined scenario receive a bigger weighting in the predicted outcome, whereas in standard stress tests each period is equally weighted). They can be useful when some aspect of an historical scenario is expected to reoccur and the scenario is of an appropriate magnitude. However, such scenarios are backward looking and may lose relevance through time (Ruban and Melas, 2010). As the Bank for International Settlements (BIS, 2009) notes "the severity levels and duration of the stress indicated by previous episodes proved to be inadequate. The length of the stress period was viewed as unprecedented and so historically based stress tests underestimated the level of risk and interaction between risks."

Hypothetical scenarios consider plausible future developments. They allow a flexible formulation of an event and can use a mixture of elements. For example, a shock from a previous historical event can be combined with other developments that never occurred. The advantage of such scenarios is that they can be tailored to be relevant to the risk profile of the portfolio. However, the building of a well-articulated hypothetical scenario can be a labour-intensive process, especially if the underlying model considers many factors, and it is important to understand the implicit assumptions made in scenario construction. Unlike historical scenarios, hypothetical scenarios can involve simulating shocks that reflect structural breaks that never occurred. For example, one could create a hypothetical scenario that examines the impact of a country exiting the euro zone by making a prediction of returns, volatilities, and correlations that would apply in this scenario. However, it may be difficult to convince decision makers that truly innovative scenarios are plausible and so the construction of hypothetical scenarios can still be limited by historical events. As BIS (2009) notes: "Scenarios that were considered extreme or innovative were often regarded as implausible by the board and senior management."

Deterministic vs. stochastic

The modelling used in these tests can be either *deterministic* or *stochastic*. With *deterministic stress testing*, scenarios are defined a priori without any reference to their likelihood. With *stochastic stress testing*, scenarios are randomly generated to produce a distribution of results on the basis of distributions of the underlying assumptions.

The European Insurance and Occupational Pensions Authority, EIOPA, conducted a survey (EIOPA, 2008) of protection mechanisms for pension funds across the region, including looking at solvency technical provisions. Three different approaches to risk assessment were defined as follows:

1. *Stochastic approach* (DK, NL, PL, and SE) employs randomly generated scenarios and delivers outcomes of a resulting probability distribution of one or more target variables. Stochastic models are suitable to incorporate policy rules and the corresponding control and adjustment mechanisms. This approach requires advanced modelling expertise and makes use of parameter estimations based on historical observations.

2. *Deterministic approach* employs predetermined, fixed scenarios (AT, DE, DK, FR, NO, PL, and SE). These often include an expected (*best-estimate*) scenario and a downturn scenario that may vary the degree of severity. A typical stress test would assess the resilience or vulnerability of the

system to an "extreme, but plausible" event. The scenarios can be based on historical events, but may also be hypothetical in nature. A deterministic approach is usually easier to implement than a stochastic approach.

3. *Tailor-made approach* takes into account the specific circumstances and risks of individual pension schemes (BE, ES, HU, IE, IT, LU, PT, and UK). This approach is flexible and offers scope for tailor-made solutions that take into account the specific risk profile of the IORPs (Institutions for Occupational Retirement Provisions). According to the specific situation, it may encompass a stochastic approach, a deterministic approach, or a combination of both.

Blake, Cairns, and Dowd (2001) argue that stochastic simulation is the appropriate vehicle for designing and stress testing any pension plan. However, while stochastic techniques appear to provide a richer set of results, their weakness lies in exactly on how close to reality the assumed distributions are.

Reverse stress testing

One particular type of stress testing which has been gaining prominence in other financial sectors is what is known as '*reverse stress testing'* (for example, the FSA in the UK is requiring such testing from banks). Traditional approaches to stress testing first define what qualifies as a significant deterioration in portfolio risk factors and then assess the impact of these changes on the portfolio. For example, one might examine the impact of the rise in US interest rates by 100 bps on an international government bond portfolio. *Reverse* stress testing, on the other hand, is used to assess the resilience of a portfolio to extreme events by identifying which particular events could lead to losses that exceed a given level. It starts from an outcome, such as a portfolio loss, and identifies the circumstances that would cause this outcome to occur. Thus, reverse stress testing provides an insight into likely scenarios that are the most relevant to the loss profile of a portfolio (Ruban and Melas, 2010).[7] The advantage of such tests is that they force forward looking scenarios rather than historic scenarios to be examined, and can focus attention on extreme results (Deloitte, 2011).

V. Experience with stress testing pension funds

Within the pension sector, before the financial crisis, stress testing DB pension funds was a more widely used practice than stress testing DC funds. The reason for this is a practical one: DB plans provide a benefit guarantee or promise and must therefore manage their assets closely with regard to their liabilities. The purpose of stress testing in a DB context is precisely to determine to what extent the assets may be sufficient to meet future payments, given different risk scenarios. As it has already been mentioned, for DC pension funds, the question arises of "what to stress test the pension fund against". This is still a challenging question, with no general practice among supervisors.

As in the banking and insurance sectors, the financial crisis has raised the profile of stress testing amongst pension funds and their supervisors. A 2011 MSCI survey (MSCI, 2011) of 85 pension funds, endowments, foundations, and sovereign wealth funds notes that the number of pension funds stress testing their assets has increased markedly since 2009 (66% vs. only 27% in 2009), as schemes are more and more concerned about market risk, counterparty risk, and liquidity risk. The pension funds and other financial

[7] Ruban and Melas (2010) consider two methods for conducting reverse stress tests using a multifactor model. The first approach derives the expected returns to all factors given a portfolio loss. This takes the factor composition of the portfolio and derives how the portfolio loss is expected to be distributed among the different factor components. The second approach investigates single factor shocks, using correlated stress tests, that could lead to a certain portfolio loss. This approach is said to be particularly useful when the portfolio or risk manager is concerned about the possibility of negative developments in specific factors.

institutions which responded to MSCI's survey reported that while stress testing was seen as critical for integrating qualitative and quantitative information, enterprise risk management, and liquidity and counterparty risk analysis, integrating stress testing with mainstream risk management practices can be challenging. In other words: "stress testing has so far been seen as the acupuncture and herbal remedies corner of risk management, but perceptions are changing".[8]

Supervisors are also increasingly making use of stress testing techniques. Yet stress testing for pensions still lags behind other financial sectors, such as banking and insurance, as seen in the recent survey of IOPS Member pension supervisory authorities. According to the results of this survey (cf. Annex 1), only 40% of responding supervisory authorities (12 out of 30) undertake stress testing on pension funds (with different approaches: ongoing vs. ad-hoc basis, individual pension funds vs. the industry as a whole, one factor vs. "scenario analysis" involving multiple factors). Half of the responding IOPS members mentioned that pension funds in their jurisdiction undertake their own stress tests, but only around one third of these are DC.

The table below summarizes the types of stress tests that are run in different IOPS member and non-member jurisdictions:

Table 1. Types of stress tests run in different IOPS jurisdictions

Country	Type of pension funds	Type of stress tests
Chile	DC	Minimum return, VaR
Czech Republic	Hybrid	Baseline scenarios with macroeconomic variables
Germany	DB	Four scenario stress test: bonds only, equities only, bond and equity, equity and property
Iceland	DB	Funding ratio against a number of 10 critical variables
Israel	DC	Identifying main sources of market risk for the risk free rate, spread, equity market and foreign exchange rate
Mexico	DC	VaR
Norway	DB	Early warning analysis and tests run on market risk, insurance risk, counterparty risk, operational risk

Source: IOPS Survey, Supervisory authorities' responses.

[8] Riccardo Rebonato, "Number-crunchers crunched", *The Economist*, 13 February, 2010.

Defined benefit pensions[9]

When the issue of stress testing is raised in relation to pensions, the topic which most immediately comes to mind is stress testing the solvency of pension funds (Gisler, 2010) and their ability to meet any promised payouts or returns. Sensitivity testing or scenario analysis can be used – i.e. examining the impact of a particular factor or a more complex scenario on whether such payments are likely to be made.

Testing is usually done against financial factors (i.e. a decline in certain investments or a portfolio as a whole), but other risk factors, such as mortality, are also important. The sensitivity and robustness of assumptions behind liability valuations may also be tested.

This sort of stress testing generally applies to defined benefit (DB) pension plans, with the aim being to see if the plan is sufficiently funded to meet its obligations even in adverse circumstances. DB funding or solvency rules typically require assets to exceed liabilities by a solvency margin. The solvency margin might be calculated as a simple percentage of liabilities. Alternatively, the solvency margin can be risk weighted (i.e. with a higher margin required to be held for assets which are perceived to be more risky).

For example, it is interesting to compare different sensitivity tests and the level of factor risk which are used in various solvency tests for pensions and insurance companies in different jurisdictions (see Table 1). It is interesting to note that while in the Netherlands the stress test is part of the risk-based solvency requirement, in Denmark and Sweden it is a supervisory tool used to evaluate the financial soundness of an institution in order to determine a supervisory response (see Table 2). The traffic light system employed in Denmark checks whether a fund would be put into theoretical insolvency as a result of a mild or a moderate shock related to the risk factor (equity, fixed income, real estate). Thus, for example, a fund is classified to be in a red zone if it could not withstand a 12% drop in equity prices and in a yellow zone if it becomes theoretically insolvent in the case of a 30% drop in equities (cf. Brunner *et al*., 2008).

[9] DB stress testing has been examined in detail by the IMF (Impavido, 2011). The topic has also been covered previously by the IOPS – see IOPS Toolkit for Risk-based Supervision, Module 2, *Quantitative Measures of Risk*, www.iopsweb.org.

Table 2. Sensitivity tests used in pension/insurance solvency ratios

	Solvency II[10]	Netherlands (FTK)[11]	Sweden[12]	Denmark
Equity	30% stress test listed and private equity	–25% mature markets' equities –35% emerging market equities –30% private equity	–40% Swedish stock market – 37% foreign equities	Red –12% Yellow –30%
Fixed income	0% capital charge for European government bonds – whatever their credit rating	based on approximately a +/– 1 percentage point change in term structure of interest rates		Red +/– 0.85% Yellow +/– 1.2%
Real estate	– 25% for real estate and infrastructure debt	– 15%	–35%	

Source: IOPS Survey, Supervisory authorities' responses.

[10] Solvency II uses a value at risk measure (VaR) at a 99.5% confidence interval over a one year time horizon (i.e. 1 in 200 year event). Solvency II uses a modular approach in the standard formula whereby the main risk categories are separated as market/underwriting/default/operational/intangible asset risk. Market and underwriting are then subdivided into sub-risk categories.

[11] FTK standardized approach considers the shocks listed to have a 2.5% probability over a one year horizon.

[12] Traffic light test applied to insurance companies and *pensionskassor*.

Figure 3. 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.	Market yield curve measured by Euro swap curve.	5% of Technical Provisions (from EU IORP Directive). Measured once per year using current market values. Maximum period for correction of deviations: 3 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 25-35% (depends on type); currency 20%; real estate 15%. Maximum period for correction of deviations: 15 years.
Denmark	Fund-specific mortality table approved by actuary and supervisor. Traffic light stress test includes assessment of the impact of a 5% improvement in longevity.	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 every 6 months using current market values. Period of correction from minimum required standards: 1 year.	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 +/- 0.85%, yellow +/- 1.2%

Source: Brunner et al. (2008).

As the IMF paper (Impavido, 2011) explains, stress tests are often used to complement risk weighted solvency margins. Risk weighted margins are affected by model risk and might not provide a reliable solvency estimate needed to withstand adverse conditions. Stress testing overcomes this weakness by requiring plans to calculate the additional amount of assets it would need to be able to meet its obligations under a prescribed stress scenario or scenarios. It is complementary to risk weighting as it generally uses the standard or accepted internal model to conduct the necessary calculations under the different scenarios of increasing but still plausible severity. Similarly to the banking and insurance world, the stress testing results are used by the supervisor to graduate the policy and supervisory responses, with more intense scrutiny devoted to pension plans with poorer results.

Supervisors use various techniques for monitoring the different sources of risk affecting the solvency position of DB plans. These include sensitivity testing using different actuarial factors, the analysis of sources of earnings, roll-forward calculations, VaR calculations, duration and maturity gap analysis, and deterministic and stochastic stress testing.

While these techniques are discussed further in the IMF paper (Impavido, 2011),[13] an example of using such techniques by the supervisor is the 'Early warning analysis' conducted by the Norwegian FSA. This exercise refers to collecting and analysing key figures from the largest 42 pension funds with the intent to identify the most vulnerable, focusing on those with a high risk profile compared to their available buffer capital. In Iceland, according to the new imposed guidelines on risk management, pension funds stress test their funding ratio against a number of ten critical variables and deliver the result to the Icelandic authority.

Reverse stress testing can also be used for DB pension funds, working 'backwards' to see how badly certain factors or scenarios would have to be before liabilities could not be met. However, these tests can be more complicated for pension funds than other financial sectors, as other means of protection (such as sponsor covenant, pension guarantee schemes etc.) may also be in place to make sure that pension benefits are paid.

Hybrid pension plans

Stress testing can also be applied to other types of (hybrid) pension plan, where some form of guarantee is involved. This is the case for pension funds in the Czech Republic, whilst the funds in Chile have a minimum return guarantee, which is relative to the returns of the sector. Further details of these stress tests are included in the Annex 2.

Defined contribution pensions

Although in principle stress testing can be applied to at least investment risks in DC pension funds, there are few examples of its application, and it is too early to be able to draw lessons from country experiences.

Sensitivity tests and scenario analysis can also be applied to DC pensions which have no set liabilities or obligations to meet in terms of pay outs. The main examples of such stress tests are the Israeli, Australian, and Mexican stress tests. The Israeli and Mexican stress tests focus on the risk around the market value of the DC fund's portfolio of assets.[14] The Australian stress test, on the other hand, focuses on liquidity risk.

For the Israeli supervisor, the implementation of the stress test involves identifying the main sources of market risk for the main asset classes, namely equity, government bonds, deposits, loans, corporate bonds, and overseas investments. Changes in risk factors according to various scenarios are then applied to the portfolio (i.e. an endogenous shock vs. an exogenous shock to the Israeli market).

[13] See also IOPS Toolkit for Risk-based Supervision, Module 2, *Quantitative Measures of Risk*, www.iopsweb.org.

[14] Such tests on DC pensions would be similar to the stress tests which the Federal Reserve in the United States has proposed implementing for mutual funds – see Reuters, 29/6/2012 '*Fed Official Floats Stress Tests of Money Market Funds'* http://www.reuters.com/article/2012/06/29/us-usa-fed-rosengren-idUSBRE85S0MN20120629. This follows 2010 reforms of money market rules adopted by the Securities and Exchange Commission: http://www.sec.gov/rules/final/2010/ic-29132fr.pdf

Table 3. Scenario testing of Israeli pension funds against various sources of market risk

Simulated local shock	Historic-based scenario 4th Quarter 2008
Equity –30%	Equity –29.8%
Corporate Spread 200bp	Corporate –9.4%
Risk free interest rate +20%	Government (+deposits) –4.6%
Forex –20%	Foreign investment –15%
	Loans –4.4%

Source: CMISD (Israeli supervisory authority).

In Mexico, the historical VaR is the primary quantitative financial risk supervision tool. The pension fund management companies (AFORES) have to compute and comply with the VaR limit daily and also have to complete a stress test using parametric VaR and Monte Carlo VaR to further evaluate and monitor risk and to make investment decisions. Additionally, AFORES must have stop-loss rules, such that specific measures can be taken if losses are incurred above a certain level. The regulation is not specific with respect to prudential policies to manage risks, but it imposes portfolio re-composition when any quantitative limit is exceeded, including the historic VaR limit. However, The National Commission for the Pension System (Comisión Nacional del Sistema de Ahorro para el Retiro, CONSAR) has introduced a certification process for both AFORES technological infrastructure and employees capabilities to master derivatives instruments requiring proper risk management. Each pension fund (Siefore) must have a manual (checked by CONSAR) describing all the procedures, including computing marginal VaRs for assessing the risks of investing in specific types of instruments.[15].

In Australia, the Australian Prudential Regulation Authority (APRA) has recently introduced a stress testing requirement for superannuation funds, as a response to the shocks and uncertainty caused by the financial crisis. Stress tests were previously carried out, but there was no formal obligation from the regulator. The new stress tests are targeted at liquidity risk. They construct harsh, but plausible, scenarios and apply them across the investment portfolio to assess on-going liquidity.

Even though particular attention is given to liquidity stress testing, the Australian regulator also provides guidance on investment risk stress testing. Recently, APRA issued a Prudential Standard SPS 530 on Investment Governance[16] that entered into force on 1 July 2013. According to this document, trustee applying for a superannuation license must first submit an investment strategy which "determines appropriate stress scenarios that cover a range of factors that can create extraordinary losses or make the control of risk in the investment strategy difficult", and undertake stress tests based on the previously mentioned scenarios prior to the implementation. Furthermore, the stress testing program submitted should respect a number of requirements set out in the prudential standard: "including, at a minimum, the

[15] See IOPS Toolkit for Risk-based Supervision, Module 2, *Quantitative Measures of Risk*, www.iopstoolkit.org.

[16] See: http://www.apra.gov.au/Super/PrudentialFramework/Documents/Final-SPS-530-Investment-Governance-July-2013.pdf.

performance of each investment option against the stress scenarios required", a description of methodology used, and a periodical review by senior management.

One of the main criticisms of the VaR kind of stress tests for pension funds is that these are often based on short-term horizons (they were initially designed for banks), and therefore the question is raised as to how useful they are for long-investment horizon institutions, such as pension funds.[17] Can stress tests based on one day, one month or even one year moves provide an appropriate measure of risk for pension funds which may have a 40-year-plus investment horizon (or longer if the payout phase is also considered)?

Alternatively, some form of target or retirement income goal can be designed for a DC plan, and the probability of meeting this target under different conditions tested. For example, stress tests run by the Australian pension funds required varying levels of sophistication, and although there are only some funds carrying tests around a target return, their number is increasing.

Governance and supervisory requirements for stress testing

As a risk management tool, stress testing relies on strong governance, a solid and transparent methodology, and effective reporting to achieve its goals. The governing body of the pension fund has responsibility for the institution's risk management strategy and is therefore also the main decision-maker with respect to stress tests.

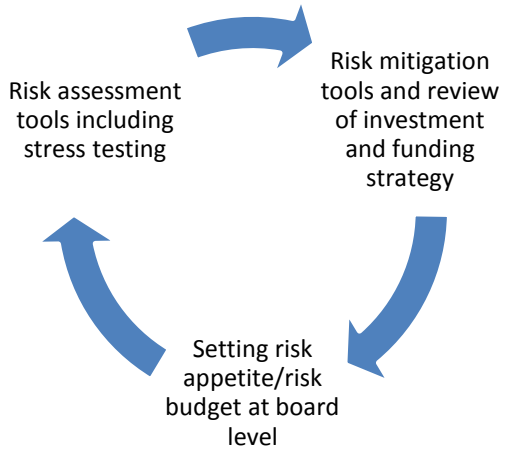
The stress testing methodology itself needs to be reviewed and updated regularly, in line with major changes in market conditions and the macroeconomic environment. Given the technical complexity of stress testing, the governing body may rely on a special committee, such as a risk committee, to design, run, and review stress tests.

Among other things, the governing body needs to decide on management requirements for the chosen stress testing tool and to ensure that the tool is proportional to the size and resources available to the pension fund. For smaller funds, it is likely to be too costly to build their own sophisticated stress testing models and hence they may need to rely on simpler methods to assess risk, such as those developed by the supervisory authority. A similar approach is taken in the banking and insurance sectors.

The typical approach to risk management, including the role of stress-testing, is described in Figure 4. The process starts at the board level, setting the risk appetite (or risk budget) and ends with the identification of risk mitigation tools.

[17] This is not an issue if the member preserves his withdrawal benefit or invests in similar asset. For a DB plan, stochastic modelling can incorporate the time horizon as a parameter: the objectives of the modelling exercise should include a defined time horizon over which the performance target is measured, within quantified confidence levels.

Figure 4. Risk management cycle



In order for stress testing to deliver value to the organisation, it is also necessary to ensure that there are effective reporting channels in place. The reporting capability of the institution must be able to provide internal and external stress testing reports in an efficient manner, ensuring that the information flows at appropriate times and with appropriate frequency. It must also provide for a seamless link to up-to-date market data to ensure the relevance of the stress testing function, as well as automatic data quality controls. The stress testing reporting platform must also be sufficiently flexible to allow for new risk factors to be introduced as well as for adapting the methodology to possible changes in regulatory requirements.

Similar requirements can be considered for the implementation of a stress testing platform within the supervisory authority – that is governance, methodology, and reporting, which are the three essential aspects for the effective functioning of stress testing. Staff resourcing and capabilities for stress testing supervision are key challenges for many supervisory authorities. The implementation of stress testing is ideally done by a person or unit dedicated to such a task, but limited resources may stand in the way. Only a few pension supervisors have established units specifically dedicated to stress testing. Data and IT systems are also key ingredients for implementing effective stress testing programmes.

For example, the UK Financial Conduct Authority (previously FSA) emphasises the importance of stress testing in the authority's new supervisory approach and regulatory architecture. Following the FSA's experience of stress and scenario testing,[18] supervisors could build an integrated approach to stress testing. This consists of three main elements: pension funds' stress testing, the authority's stress testing of specific pension funds (i.e. the ones with the highest impact), and simultaneous system-wide stress testing. This approach could be viewed as a way of standardising the impacts of tests and create a certain coordination in terms of the primary objective followed by any supervisory authority – prudential supervision.

The supervisor could also introduce recommended scenarios for pension funds to run from time to time, without necessarily taking responsibility for the outcomes. The supervisor should be clear that the ultimate responsibility rests still with the pension fund's senior management, but the fact that the supervisor sees the 'big' picture and does not suffer from 'disaster myopia'[19] is a good argument to

[18] FSA, Stress and Scenario Testing, 2009.

[19] 'Disaster myopia' refers to "the agents' propensity to underestimate the probability of adverse outcomes, in particular small probability events from the distant past" (Haldane, 2009).

consider that there is added value in the scenarios recommended by the authority in order to complement the internal scenarios of pension funds.

Recommended scenarios or simultaneous system-wide stress testing designed by the supervisor could use as input a broad macroeconomic scenario that the authority sees as a possible concern or a source of threat to the stability and safety of the pension system in general. However, it may be useful if the scenario designed for the simultaneous stress test differs from, and is wider than, the recommended scenarios in order to reflect the different objectives of the tests, the former being used to observe system-wide impacts, while the latter is focusing on the impact on a specific pension fund.

The question that immediately comes to mind is what the supervisory authority does with all the (new) information received from pension funds, in particular how does it act based on the outcomes of the scenarios or stress tests. Firstly, it is highly probable that the supervisor may be in need of more resources in order to run system-wide tests, and in-house modelling capability to compile all the results, both from own analysis but also from the results received from pension funds. Secondly, the supervisor would need to integrate output in the existing framework of assessing the pension funds (for example, in the overall risk-based supervision methodology).

In addition, the supervisor needs to make various decisions regarding the use of stress tests:

- to what extent pension funds will be allowed to use their own methodology and how much flexibility they will have in designing internal models;
- whether stress testing will be a part of on-site or off-site supervision;
- the frequency of stress testing;
- the scope of the stress testing, ranging from a focus on given risk factors to a fully-fledged risk assessment covering all main risks and different scenarios;
- the supervisory action to be undertaken given the results of the stress tests.

Further analysis needs to be conducted in order to be able to identify lessons and good practices of stress testing, particularly in a DC context. More jurisdictions supervising DC pension funds should realise the importance of the stress testing tool and integrate it into their legal and prudential framework. A future IOPS project could develop ‘best practices’ for stress testing in DC pension funds, addressing governance requirements, reporting, and technical tools.

VI. Conclusions – how to improve pension stress tests

Stress testing – using the broadest term, referring to factor sensitivity testing and scenario analysis – has become more important for the financial sector generally and also for pension funds since the financial crisis. However, this is still a relatively new tool and there is a growing consensus that better design and implementation of stress testing is needed.

In the case of pensions, there are still only a few jurisdictions where supervisors use them regularly. There is also ongoing concern over their relevance and applicability to DC pension systems. In the case of DC plans, supervisors do not have to have a “tangible” outcome to stress test. For example, the Mexican authority tests a short-term measure of risk, the VaR, while the supervisory authority in Israel stress tests portfolios’ resilience to various risks scenarios. In Australia, APRA has recently started carrying out stress tests of liquidity risk.

It is worth remembering that even though stress-testing for DC schemes is performed to analyse the impact of various risk factors (such as liquidity, market risk, foreign exchange risk etc.) on the current or projected situation of the pension funds, this procedure should take into account the ultimate long-term goal of the pension funds, i.e. their ability to deliver adequate retirement income for its members.

The take-up of stress testing is also limited by lack of understanding among senior management, both within supervisory authorities and pension institutions.

As this report has highlighted, stress tests are still not widely used in the pensions sector covered by IOPS jurisdictions. Only 40% of supervisory authorities use stress tests, mainly in DB plans, and as part of a risk-based solvency assessment. Pension supervisors still have some way to go before they catch up with their banking and insurance peers.

Supervisors need to be sure what stress tests are for and what supervisory authorities are trying to achieve – particularly when it comes to testing DC pensions. Stress testing is a relatively straightforward task for DB pension systems, where supervisors and funds are used to test solvency and funding levels against adverse conditions. However, the challenge is greater for DC funds. Testing the impact on portfolios of market downturns and other risk factors, though a useful part of portfolio risk management, only gives half the story. What supervisors and members of DC funds really need to know is whether this accumulated pension pot will deliver them an adequate pension. Some supervisors (and indeed funds) are therefore looking at how to introduce 'artificial' income targets for DC funds, which can be stress tested. Further work on these targets and their measurement will be undertaken by the IOPS in 2014.

As most experts attest, the key to getting stress testing right is not so much the algorithms and mathematics of the tests themselves, but rather coming up with a plausible scenario to test against. Any stress test is only as good as the scenario on which it is based. As an exercise of the imagination, the stress test is limited by the imaginative capacities of those designing the stress test scenarios. As the IAIS (2003) points out: "Straightforward tests, with simple assumptions that cover the major risks, may be more useful than complex modelling that is difficult to understand or to validate."

But ultimately, the effectiveness of stress tests does not depend on just a few parameters, but on the context within which they are conducted. This requires a clear *ex ante* understanding of the stress tests' objectives; knowledge of the key individual financial institutions in the system, their business models, principal sources of risk, and main channels of risk transmission; appropriate decisions on the tests' perimeters and coverage; the use of other complementary assessment tools; a communications strategy tailored to the circumstances and purpose of the tests; and a credible commitment to take the measures that may be required to address the vulnerabilities uncovered by the tests. Lastly, the principles also emphasize that, regardless of technical refinements and improvements, stress tests will always remain hypothetical statements and cannot, by themselves, predict or prevent crises.

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ANNEX 1: USE OF STRESS TESTS FOR PENSIONS IN IOPS MEMBER JURISDICTIONS

Country	Supervisory authority	Pension funds	Comments
Austria	✓	✓	The FMA performs a scenario analysis for pension companies twice a year. The impact of certain unfavourable capital market developments on stakeholders of the pension funds (employer, employee) is tested. Therefore, the entire assets (divided in several asset classes) of each investment and risk sharing group is considered. The aim of the scenario analysis is to illustrate in a transparent way any pension cuts for beneficiaries, guarantee payments of the pension companies and employer compensations for deficiencies in case of DB plans over a five-year period. – On-site inspection on risk management, where the current risk within the asset portfolio is assessed. – The quarterly reporting (quarterly financial statement) of assets is based on the principle “substance over form”. Therefore, all risks have to be reported with their notional value (exposure). – On the basis of the quarterly financial statement, key indicators are derived, which are used as input for the quarterly assessment of the risk situation of the pension companies
Brazil	X	✓	The National Superintendence of Complementary Pension Funds (Superintendência Nacional de Previdência Complementar, Previc) is aware that many Brazilian funds, both DB and DC, employ stress testing of their pension plans; however, the authority does not keep track of the plans that undertake stress tests, or of the tests employed. Previc assesses risk both on the on-site and on the off-site supervision. The selection of plans for on-site

			supervision uses a risk matrix that takes into account the many risks involved – actuarial, governance, investment, etc.; on the off-site supervision, there is a risk matrix for investments of the plans and another one for actuarial risk.
Chile	✓ (DC)	✓ (DC)	Since 1981, the DB part of the Chilean system is closed to new members. Moreover, the DB pensions are financed by the government using general tax revenues. Therefore, the Superintendence of Pensions does not produce stress testing exercises in this case. The Superintendence of Pensions undertakes a monthly stress VaR and a minimum return guarantee exercise. These are described in the Annex 2. Even though it is not mandatory, some pension fund managers undertake stress-testing exercises as part of their risk management tools. Since undertaking these exercises is not mandatory by law, the Superintendence is not free to disclose details about their methodologies and results. In addition to the minimum return and stress VaR exercises, the Superintendence periodically elaborates a risk assessment report. This document contains information on the returns obtained by pension funds, as well as the absolute and relative risk associated with each fund. Regarding the absolute risk faced by pension funds, this is quantified using three different measures. Namely, the variance of historic returns (estimated with an exponential decay factor); the VaR of the fund; and the stress VaR. The relative risk faced by pension funds is measured by their tracking errors. In this case, the benchmark used for each manager's pension fund is the "system fund" composed of all the funds of the same type (e.g. the benchmark for manager *i*'s type A fund is the fund composed of the sum of the portfolio holdings of the rest of managers' type A funds). The estimation of these risk measures makes it possible to construct risk-adjusted performance metrics, such as the funds' alpha and the information, ratio, and Sharpe ratios. Using these reports, the Superintendence is able to identify the main risk' concentrations and exposures, both at the individual fund manager and system levels.

Colombia	✓ (DC funds)	✓ (DC funds)	Stress testing procedures are undertaken by us under different scenarios. For example: Scenario number 1: Increasing by 100 basis points the long-term interest rate. Scenario number 2: Increasing by 100 basis points the long- and short-term interest rates. Scenario number 3: Increasing by 100 basis points the short-term interest rate and by 200 basis points the long-term interest rate. Scenario number 4: Testing the market value of equity portfolio if the price suffers a change of 14.78%. According to the regulation issued by this Superintendence, on the methodology of market risk assessment, pension funds must have an internal model which must be able to undertake stress testing for different risk factors, and if the market presents significant changes that are not reflected in the historical data used to undertake this stress testing, then the model must include these changes for the different risk factors. In the case of risk involving the price of shares with low, medium or non-existing trading activity or non-listed shares, the model must take into account stress scenarios with the necessary research and information based on own assessments of the pension fund. Quarterly, there's an internal report with the VAR calculation for the different pension funds, involving different risk factors.
Costa Rica	✓ DC	X	Costa Rica recently made a stress testing exercise. It included banks, other financial institutions, brokerage firms, mutual funds and pension administrators (DC). The exercise used a macro-prudential approach and the scenario analysis was: 1. A real shock (GDP abruptly falls, has negative impact on employment, the exchange rate and interest rate). 2. A financial shock (capital flight). The supervisory authority asked for transmission channels, methodologies to assess the impacts, assumptions

			and a set of financial indicators to measure capital needs.
Czech Republic	✓	X	The Czech National Bank (CNB) supervises pension funds on an individual basis (strict investment limits are set by law, off-site as well on-site inspections are used). In addition, top-down stress tests on pension funds to identify risks in individual institutions, as well as the industry as a whole, are also performed as a part of Financial Stability Department tasks and, published in the Financial Stability Report on an annual basis.
Germany	✓	✓	DC funds do not operate in Germany. Bafin undertakes stress testing on insurance companies (including Pensionskassen) and not on Pensionsfonds. The supervisory authority has various, future-oriented tools at its disposal as an early warning system. One of these tools is the stress test, which assumes a possible, but uncertain, development in the capital market.
Gibraltar	X	X	The jurisdiction does not undertake any stress tests of pension funds due to the limited number of pension schemes that currently need to be regulated by the jurisdiction. Most pension schemes invest in listed instruments via a licensed investment manager or invest into an insurance product. We conduct a Risk Assessment of all pension schemes regulated by the Commission.[20]
Hong Kong	✓ (DC funds)	✓ (DC funds)	The Mandatory Provident Fund Scheme is one of the pension systems in Hong Kong. The funds offered under the Mandatory Provident Fund Scheme (MPF funds) are required to report their financial position on an annual basis, according to the applicable accounting guidelines. The accounting guidelines require the fund to provide disclosures in the financial statement that enable users to evaluate, among other things, the nature and extent of risks arising from financial instruments to which the fund is exposed and how the fund manages those risks. The relevant risks may include credit risk, liquidity risk, and market risk. For the market risk, sensitivity analysis would be used to show the effect on the net assets of the funds attributable to fund-holders of "reasonably possible changes" in the relevant risk variables such as price risk, interest rate, risk and currency risk. However, the "reasonably possible change" that covers only the period until the next annual reporting period should not include remote or "worst case" scenarios or "stress tests". The accounting guidelines permit the

[20] For further details on the process please refer to: http://www.fsc.gi/firms/riskframework.htm.

			fund to use a sensitivity analysis that reflects interdependencies between risk variables, such as a value-at-risk methodology, if it uses this analysis to manage its exposure to financial risks. Guarantors of MPF funds with capital or investment guarantees (MPF guaranteed funds) are required to maintain adequate reserves to provide investment guarantees: 1. Banking institutions acting as guarantors of MPF guaranteed funds are required to meet capital adequacy and provisioning requirements prescribed by the Hong Kong Monetary Authority. Minimum standards require calculation of market risk capital charges using a value-at-risk approach at 99% one-tailed confidence. 2. Insurance companies acting as guarantors of MPF guaranteed funds are required to meet reserve requirements prescribed by the Office of Commissioner of Insurance. The minimum benchmark requires the provisioning to cover all liabilities of the insurer in respect of the fund, which includes a provision for investment guarantees that covers most of the adverse situations, i.e. results from stochastic modelling with 99% confidence.
Hungary	X	✓ (DC)	DB funds do not operate in Hungary. In 2010, several private pension funds undertook their own stress tests of their income. According to government measures, mandatory private pension contributions were transferred to the state pension system and pension funds examined the future opportunity of operation. The authority closely supervises the use of operational reserves of private pension funds. The Central Bank of Hungary applies complex risk assessment methods using quarterly and yearly data. Pension funds are obliged to submit data on their operation yearly and quarterly. If the data refer to some kind of risk, the Authority takes mitigating measures. The complex risk assessment method generates indicators from the data. These indicators may refer to increases in certain risks between quarters or years. The methodology for instance uses the following indicators:

			Strategy • market share based on the fund's assets, • market share based on the fund's membership, • change in the number of members, • change in the number of passive (non-contributing) members. **Exchange risk** • difference in benchmark return and pension fund return, • net rate of return compared to average rate of return of sector. **Operational risks** • proportion of asset management fees to assets, • change in investment incomes and investment expenditures, • operational costs per capita, • proportion of administrative fees/marketing fees to total operational costs. **Liquidity risk** • change in operational incomes/expenditures, • proportion of pension payments to funding reserve. Quantitative risk assessment is complemented by qualitative assessment based on other information on the institution and the sector.
Iceland	✓	✓	The Icelandic FSA does a general estimation on the funding ratio of all pension funds. This is done annually based on the latest funding ratio following the annual statement.

			According to the newly imposed guidelines on risk management, pension funds have to stress test their funding ratio based on ten critical variables and deliver the results to the Icelandic FSA. This has been so far a basis for what-if analysis, but is still under development.
India	X	X	The National Pension System Trust (NPST) gets the portfolios held by Pension Fund Managers (PFMs) evaluated on a quarterly basis by a third party research organisation, with the Sharpe ratio and standard deviation as parameters.
Israel	✓	X	The Capital Markets, Insurance and Savings Division (CMISD) of the Ministry of Finance undertakes stress tests for the long-term savings (LTS – provident funds, new pension funds – DC and life insurance policies) vehicles in Israel on an *ad hoc* basis – for the industry as whole and for single LTS providers. The stress tests are based on the investment side of LTS providers (for example the impact of the 2008 scenario on LTS portfolios).
Italy	X	✓ (DB)	The Pension Funds Supervision Commission (COVIP) regularly checks the exposures of several groups of pension funds (mainly of the DC kind) to major market risks (equity – currency – exposure to government and corporate bonds), and compares them with results in terms of performance, in order to identify anomalous cases and to program the necessary further checks. However, this is not considered as a sort of "stress test".
Jamaica	X	X	**Sensitivity testing** While actuaries do not perform stress testing as part of their funding valuation reports for pension plans, the new Caribbean Actuarial Association (CAA) standard, which was passed in December 2012, requires actuaries to perform sensitivity testing. Further, the Draft Pensions Superannuation Funds (Funding and Solvency) Regulations require the testing of adverse scenarios if the funding ratio is below 150%. These Regulations however have not yet been passed by the Legislature. **Risk-based assessment** Regulated entities, including pension plans, are required to submit reports and other information to the Financial Services Commission (FSC) periodically, which are analysed by the FSC with a view to assessing

			their risk profiles. The FSC has adopted a risk-based approach in supervising the pension plans and industry as a whole. A key component of the framework for reviewing pension plans is the use of an Early Warning Risk Assessment Tool (EWR) to promptly identify the risks associated with a pension plan. Four main risk groups are assessed using the EWR, namely: 1. **Funding risk –** the likelihood that the sponsoring employer does not comply with the terms of its covenant set forth in the Trust Deed and Plan Rules and that actuarial methods used to determine employer funding for DB plans are insufficient to provide promised benefits, that is the risk that the plan assets may not be able to cover plan liabilities. 2. **Investments** – the risk that plan investments exceed appropriate levels of risk, the rate of return objectives stipulated in the plan's Statement of Investment Policies and Principles will not be achieved, and that selection/disclosure of investment options, where choices are offered, are not properly documented, among other things. 3. **Administration and compliance risk –** the risks associated with inefficient or ineffective processes involved in the administration of the plan, such as proper record keeping or interpretation of plan rules and non-compliance with the legislation and the Trust . 4. **Governance risk –** the risk that the sponsor and trustees do not adopt appropriate controls and oversight of a plan. The framework includes trend analysis.
Korea	X	X	We do not undertake stress testing of pension funds, but we examine the pension provider periodically and we set investment limits for risk assets.
Liechtenstein	X	X	In order to ensure a better allocation of resources, the FMA has chosen a risk-based approach to supervision. Based upon a review of the annual and half-yearly report and on other sources of information, we started to conduct an individual risk rating for each pension fund in 2012. This risk rating consists of 31 predefined risk

			factors which cover different characteristics of the pension funds. These risks factors also take into consideration the impact and the probability of a possible unfavourable development and are weighted according to their potential seriousness. They add up to a final risk score, which is the basis for further action by the FMA. This might include, among others, an interim audit.
Macedonia	X	✓ (DC)	Pension funds make their own 'scenario analyses' that include a variety of factors. These scenario analyses are part of the annual investment policies of pension funds and are not obligations of the regulator. In general, scenario analyses include the impact of market risks on the portfolios of pension funds. Particular scenario analyses predict the impact of the risks of not achieving the benchmark, changes in market prices of the bonds on the official markets, changes in interest rates on deposits, changes in the market prices of shares of companies and units of investment funds, and the impact of a change in the exchange rate of the domestic currency against other currencies. Since March 2011, the Agency for Supervision of Fully Funded Pension Insurance MAPAS has worked with consultants on a European Union funded project to introduce risk-based supervision. That was the reason for the Agency to shift the supervisory approach from a rules-based supervision model to a risk-based one with the primary objective of enabling a more intense focus on the highest risks in the pension system so as to be more effective at mitigating them. The secondary objective is to reduce the attention given to lower risks so as to release resources to address the higher risks. In addition, five principles have been applied: a focus of effort and attention on those risks assessed to be the most intense; the development and use of quantified measures of the risks; the selection of what activities at pension funds to examine, or take action on, according to an objective and transparent assessment of risk; the promotion of risk management by the pension funds themselves, so as to enable appropriate reliance to be placed on their systems and policies; and an emphasis on enforcement action that is effective in preventing or remedying risks materializing, rather than issuing sanctions for their own sake. The supervision process is organised so that can be seen as a cycle with off-site supervision filling the gap between and informing on-site supervision. It should be noted that the teams within the control sector are organised according to risk category rather than activities. Hence the same staff is responsible for off-site and

			on-site supervision in relation to their assigned risks.
Malta	X	X	
Namibia	X	X	
Netherlands	✓ (DB)	✓ (DB)	Pension funds need to undertake a 'continuity analysis' at least every three years (and where appropriate additionally on request of the DNB) in which they look at possible future scenarios and how these scenarios would impact the funding position of the pension fund. The continuity analysis enables pension funds to see the risks they are more vulnerable to when compared to other risks. It also allows them to analyse what the appropriate measure would be to correct an unintended or unwanted risk position. The continuity analysis must be submitted to the DNB. The DNB examines the results of the 'continuity analysis' that pension funds need to provide to the DNB. This allows the DNB to identify both individual risks and the risks for the industry as a whole. However, in addition to the continuity analysis, we do use other forms of risk assessments for DB funds, for instance through risk-based capital requirements, targeted investment investigations, and other thematic investigations.
Norway	✓	✓	DB funds. Supervisory authority also carries out early warning analysis.
Poland	• X	•	It should be emphasized that the Polish pension funds, being DC, are always solvent. The Polish pension funds (FE) do not offer future DB-like promises. Stress tests are not an instrument of the FE. The Pension Management Society (PTE) which runs a particular FE is responsible for the proper management and it bears the financial responsibility for actions of FE. In accordance with the Polish law, any low rate of return, far different from the average return of all FE, is compensated by the PTEs. The purpose of the PTEs using a stress test is to check whether it has adequate capital to cover possible low rates of return of managed FE. The Polish Financial Supervision Authority advises the use of stress tests for PTEs. Stress tests are applied to different degrees by the PTEs, because there use is voluntary. Polish law does not require the use of stress

			tests by the PTEs.
Romania	✓ (DC funds)	●	There are no DB funds established in Romania. Stress tests are performed every half year on the portfolio for each individual pension fund. We stress test the portfolios on a scenario analysis involving factors such as: interest rate shock (for all fixed income), price shock (for equity and other investments) and currency shock (for investments valued in a foreign exchange, after deducting the notional of derivatives used for covering currency risk). After performing the stress tests, we use the information to assess the impact individually on each member's account value. Besides the stress tests, every half year we assess the liquidity of each pension fund portfolio and of the assets held by all pension funds as a whole. Another form of risk assessment is the algorithm used to establish the risk grade of each fund. According to the regulations in force, a pension fund can be "conservative", "balanced", or "dynamic" depending on its portfolio structure. The algorithm uses different weights on each type of asset (fixed income, share, mutual fund, etc.) and takes into consideration the ratings of issuers and other forms of events (e.g. bankruptcy).
Spain	X	✓	It is not compulsory in our regulation. We only establish control of the investment policy principles that the companies have to take into account, the level of risk tolerance, and the liquidity of the portfolio in different scenarios. In relation to derivatives, it is said that pension funds management entities have to have internal models to estimate their risk value. Therefore, companies use their own stress testing. A lot of them use VaR methods in the analysis of the risk for their portfolios and in stress testing controls too. We analyse the pension funds' portfolios in order to identify possible risky situations as a lack of diversification of the portfolio, a big level of structured products or complex assets. We have some ratios to identify possible situations of illiquidity, causes of winding up, etc. Taking into account these parameters, the companies to be supervised by on-site inspections are chosen.

Tanzania	X	X	
Thailand	X	✓	We do conduct on-site inspection of the asset manager using a risk-based approach. There are four areas which include operation risk, portfolio management risk, customer relation risk, and prudential risk. Some asset managers may conduct stress tests on their funds under management. Basically, they test how resilient their funds under management are to historical stressed market conditions, e.g. 9-11 of 2001, the Thai capital control measure in 2006, etc.
Turkey	X	X	
Ukraine	X	X	According to the part 2. item 1, article 38 of the Law of Ukraine “On non-state pension funds”, a person who manages pension assets must follow internal rules and procedures of risk assessment and risk management which are connected with investment of pension assets that refer to the requirements determined by the National Securities and Stock Market Commission in agreement with the National Commission for the State Regulation of Financial Services. The National Securities and Stock Market Commission in agreement with the National Commission for the State Regulation of Financial Services worked out the Regulations of Requirements for a person who manages pension assets concerning the following of internal rules and procedures of risk assessment and risk management which are connected with the investment of pension assets that is confirmed by the decision of the National Securities and Stock Market Commission on 25 September 2012, No. 1282 and is registered in the Ministry of Justice of Ukraine on 15 October 2012, No. 1728/22040.
United Kingdom	X	✓	While only a few DC schemes will undertake stress testing, it is likely that more DB schemes will (many won't though)

Source: IOPS Members.

ANNEX 2: EXAMPLES OF STRESS TESTS IN IOPS MEMBER JURISDICTIONS

Chile

Minimum return stress test

In general terms, the test is an analysis of a stressed scenario during a 24 month time period, where the scenario assumes future low returns for each Pension Fund Administrator. It is observed whether or not the Administrator will be able to fulfil the "minimum return requirement" for each type of fund.

The minimum return requirement is described in Chilean Decree-Law Nº 3.500 article 37, where it is stated that every Administrator is responsible for ensuring that the annualised average real return of the last 36 months of each of their funds will be greater than a minimum return. The minimum return is:

- For the cases of funds type A and type B, the minimum return is the lower value between:
  - the annualised average real return of the last 36 months of all funds of the same type for all administrators minus 4 percentage points;
  - the annualised average real return of the last 36 months of all funds of the same type for all administrators minus the absolute value of the 50% of that return.
- For the cases of funds type C, type D, and type E, the minimum return is the lower value between:
  - the annualised average real return of the last 36 months of all funds of the same type for all administrators minus 2 percentage points
  - the annualised average real return of the last 36 months of all funds of the same type for all administrators minus the absolute value of the 50% of that return.

The following steps explain the algorithm of the Minimum Return Stress Test for a type of fund (type A, B, C, D, or E).

For the last 36 months of historical data available, calculate the following variables:

a) MR_{36m} = Minimum return requirement for the type of fund in analysis, using the methodology described in the Chilean Decree-Law Nº 3.500 article 37.

b) $SD_{36m,Administrator(i)}$ = standard deviation of the difference between monthly real return for the Pension Fund Administrator(*i*) and the monthly total real return of all Pension Fund Administrators for the type of fund in analysis (Calculate this variable for every Administrator.)

For the last 20 months, calculate the following variable:

a) $GA_{(t=j,\ Administrator(i))}$ (Gap Annualised) = Difference between the annualised real return of 36 months and the minimum return (using the methodology described in the Chilean Decree-Law Nº 3.500 article 37), where *j* goes from 0 to minus 19.

For each Pension Fund Administrator forecast the following variables for each of the next 24 months and for the type of fund in analysis:

a) $MRRF_{(t=k,\ Administrator(i))}$ (Monthly Real Return Forecast) = Administrator historical real return of the (37 – k)th month minus standard deviation calculated in step 1 ($SD_{36,Administrator(i)}$), where *k* goes from 1 to 24.

b) $ARRF_{(t=k,\ Administrator(i))}$ (Annualised Real Return Forecast) = Annualised accumulated real return of 36 months ago starting with the kth month, where *k* goes from 1 to 24.

c) $GA_{(t=k,\ Administrator(i))}$ (Gap Annualised) = Difference between the annualised real return forecast ($ARRF_{(t=k,\ Administrator(i))}$) and the minimum return(MR_{36m}), where *k* goes from 1 to 24.

d) $SDGA_{(t=k,\ Administrator(i))}$ (Standard Deviation Gap Annualised) = Standard Deviation of 20 months ago starting with the kth month of Gap Annualised ($GA_{(t=k,\ Administrator(i))}$), where *k* goes from 1 to 24.

e) $G_{(t=k,\ Administrator(i))} = (1 + GA_{(t=k,\ Administrator(i))})\text{^}(3) - 1$, where *k* goes from 1 to 24.

Finally, for the next 24 months, each Pension Fund Administrator estimates the number of months ahead in which the Administrator could obtain a real return below the minimum return for the type of fund in analysis using the following formula. The Pension Fund Administrator selects the first future month in which this variable is negative; otherwise the result table is left empty.

a) $NMMR_{(t=k,\ Administrator(i))}$ (Number of months Minimum Return) = $G_{(t=k,\ Administrator(i))}$ divided by $SDGA_{(t=k,\ Administrator(i))}$, where *k* goes from 1 to 24.

Minimum Return Stress Test – Last Report October 2012 (Estimated Month under Minimum Return Requirement)

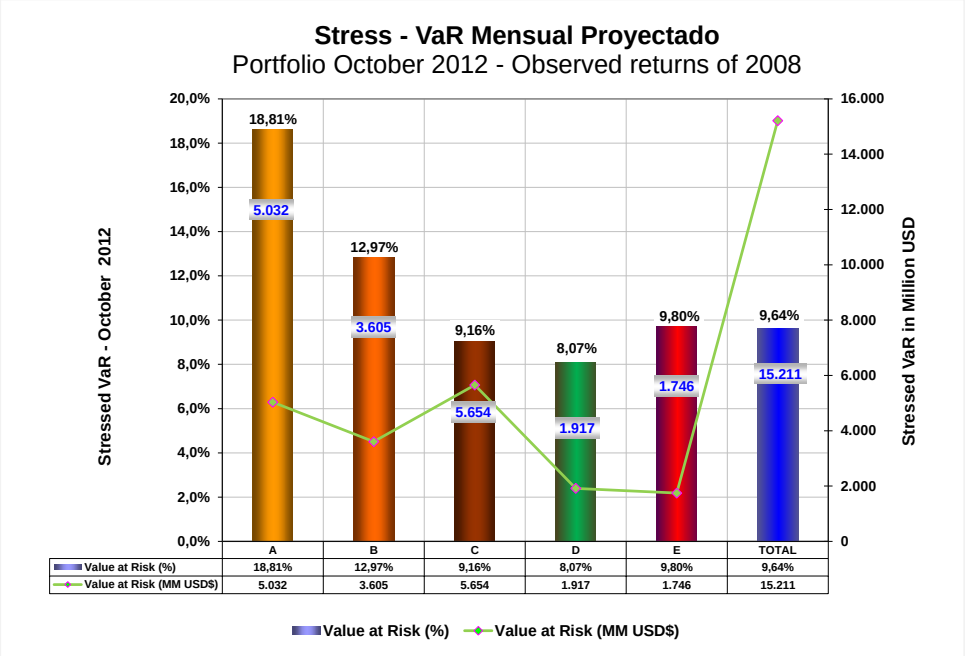
	Fund A	Fund B	Fund C	Fund D	Fund E
AFP 1					
AFP 2					
AFP 3					
AFP 4				Oct. 2013	
AFP 5					

Scenario analysis: stress testing on Value at Risk

As was already stated, the stress testing on value-at-risk (VaR) considers a historical scenario, namely the subprime crisis of 2008,[21] as a period of stress.

The VaR exercise is based on the methodology proposed by RiskMetrics in 1996. The model has 40 risk factors divided into: 12 asset classes (e.g. domestic and foreign stocks, domestic and foreign fixed income, bank deposits, etc.); eight geographical zones (developed and emerging Asia, developed and emerging Europe, Latin America, North America, Middle East and Africa, and others); and 20 currencies. In order to include the effect of currencies, the model considers all the underlying assets in which the pension funds invest abroad through mutual funds and other investment vehicles. Each risk factor is associated with an appropriate index or with an exchange rate. Weekly prices are employed, with the data sample beginning in the year 2000. The model considers the last 150 observations (three years) with an exponential decay factor of 0.97 applied to the correlation matrix, thus giving higher weights to more recent observations. Finally, a 99% confidence level is used, and portfolio returns are assumed to be normally distributed.

The Stress-VaR is estimated by the Superintendence of Pensions on a monthly basis. The next graph shows the exercise's results as of October 2012. The expected loss is about 9.64% of testing, which amounts approximately to USD15.211 million.



The highest risk, measured as a percentage of each fund, tends to be located in those funds that are more heavily invested in stocks. Indeed, during October 2012, fund A had 78.1% of its assets invested in stocks, while 21.8% was invested in fixed income. For fund E, these figures were 1.9% and 98.1%, respectively. The following table details the portfolio composition for each type of fund during October 2012.[22] Moreover, the fund that presents the highest VaR in absolute terms is fund C. This is due to the fact

[21] The loss observed in October 2008 was 11.72% of pension funds' assets.

[22] As can be seen from the figure above, while the riskier funds tend to present a higher VaR, this does not hold for fund E, whose VaR is above that from funds C and D. This is due to the marginal contribution to risk

that this fund concentrates most of the system's assets (40% versus 17%, 18%, 15%, and 11% for funds A, B, D, and E, respectively).

Asset Class	Fund A	Fund B	Fund C	Fund D	Fund E	Total
Total Stocks	**78.1%**	**57.1%**	**36.3%**	**15.9%**	**1.9%**	**40.1%**
Foreign Stocks	56.7%	35.8%	19.5%	8.3%	1.0%	24.9%
Domestic Stocks	21.4%	21.3%	16.8%	7.6%	0.9%	15.2%
Total Fixed Income	**21.8%**	**42.8%**	**63.6%**	**84.0%**	**98.1%**	**59.8%**
Foreign Fixed Income	11.5%	13.1%	14.7%	12.5%	0.7%	11.9%
Domestic Fixed Income	10.3%	29.7%	48.9%	71.5%	97.4%	47.9%
Others	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Czech Republic[23]

The Financial Stability Department of the Czech National Bank (CNB) performs stress tests on (third pillar, voluntary) pension funds. These funds are required to provide a non-negative yield (i.e. capital preservation) guarantee. These tests form part of the aggregated (top-down) macro-stress tests conducted on the financial sector on a yearly basis.

The stress tests focus on relevant risks and model losses on asset holdings in the event of adverse developments in the financial markets on a one-year horizon. The models use a baseline scenario based on the official CNB forecast which models basic macroeconomic variables, such as the exchange rate, short-term interest rates, inflation, and economic growth. In addition, two other adverse economic scenarios are applied, which are constructed based on identification of risk to the Czech economy in the near future and assumes larger shocks and consequently greater levels of stress. In the pension fund test, the focus is mainly on the following risks. Ad hoc sensitivity analysis is also conducted – e.g. revaluation of instruments held to maturity.

- foreign exchange rate risk,
- interest rate risk,
- equity risk,
- property risk,
- bond revaluation risk.

The 2010/11 Financial Stability Report notes that the pension fund sector has limited capital and in the event of financial market turmoil, shareholders would have to supply new capital. In terms of the

associated to Government and Central Bank bonds. Indeed, these instruments have an important presence in fund E. Furthermore, their coefficient of variation is relatively high, leading to a higher Stress VaR.

[23] Details of the stress tests conducted by the Czech Central Bank on pension funds in the country can be found in Section 4.2 (Assessment of the Financial Sector's Resilience) in their annual Financial Stability Report http://www.cnb.cz/miranda2/export/sites/www.cnb.cz/en/financial_stability/fs_reports/fsr_2010-2011/fsr_2010-2011_financial_sector.pdf

assessment of the impact of the stress tests on the financial sector as a whole, the *Renewed Recession* scenario, which captures a fall in economic activity and adverse developments on the financial markets, had the strongest impact of the alternative scenarios presented. Although this scenario generates smaller losses than the *Asymmetric Developments* scenario in the pension funds sector, the overall impacts on the financial sector as a whole are dominated by the results of banks and insurance companies.

Key variables in the individual scenarios
(average for given years)

	Actual value	Baseline Scenario		Asymmetric Developments		Renewed Recession	
	2010	2011	2012	2011	2012	2011	2012
Macroeconomic variables							
GDP (y-o-y %)	2.3	1.5	2.8	0.5	0.7	0.4	-4.1
CZK/EUR exchange rate	25.3	24.1	23.4	23.9	27.1	24.7	27.7
Inflation (%)	1.5	1.9	2.2	2.1	3.0	1.9	2.4
Unemployment (%)	9.3	9.1	8.6	9.4	10.4	9.3	12.0
Nominal wage growth (%)	2.0	3.7	5.4	1.0	2.6	0.6	2.1
Effective GDP growth in euro area (%)	3.0	2.3	2.2	2.1	2.0	2.0	-1.6
Credit growth (%)							
Total	3.5	3.9	4.8	1.2	-2.3	2.5	-6.0
Corporations	-0.3	2.7	4.3	1.6	-0.4	1.7	-4.3
Households	7.0	6.4	6.7	1.2	-4.8	-0.8	-9.6
Default rate (PD, %)							
Corporations	4.7	4.0	3.3	4.8	5.2	5.9	8.0
Loans for house purchase	4.4	5.0	4.3	5.3	5.8	5.5	7.0
Consumer credit	6.1	5.9	5.1	6.2	6.9	6.5	8.4
Loss given default (LGD, %)							
Corporations	45.0	45.0	45.0	48.9	53.3	49.5	72.6
Loans for house purchase	22.0	23.1	22.1	27.6	37.1	30.5	50.7
Consumer credit	55.0	54.5	51.6	55.7	61.0	55.4	68.6
Asset markets (%)							
3M PRIBOR	1.3	1.3	2.1	2.4	4.2	2.3	4.7
1Y PRIBOR	1.9	1.7	2.3	2.8	4.4	2.8	4.8
5Y yield	2.7	2.9	3.0	4.5	6.4	4.9	7.7
3M EURIBOR	0.8	1.6	2.6	2.5	3.6	1.6	3.8
1Y EURIBOR	1.4	2.0	2.9	2.8	3.8	2.5	3.9
5Y EUR yield	1.9	1.8	1.9	2.7	3.8	3.4	5.5
Change in res. property prices	-3.0	-3.5	2.8	-12.4	-4.0	-18.1	-15.2
Change in share prices	9.6	-5.0		-20.0		-40.0	
Banking sector earnings							
Adjusted operating profit (y-o-y %)	-0.4	-2.3	-1.7	-17.9	-3.0	-22.7	-6.6
Insurance sector							
Fall in premium written for motor vehicle insurance (%)		10.0		10.0		10.0	
Gross damage due to three floods (for whole sector, CZK bn)		24.0		24.0		24.0	

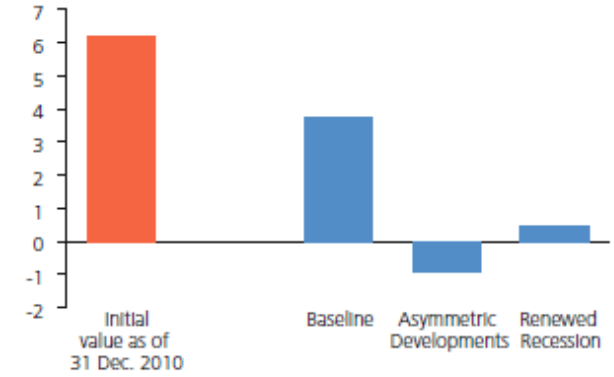
Source: CNB, CNB calculation

The report goes on to note that the capital of the pension fund sector is significantly lower than **that of the other sectors of the financial market.** The current stress tests of pension funds focus on relevant risks and model losses on asset holdings in the event of adverse developments in the financial or property

markets at the one-year horizon. The tests assume that 85% of the 2010 income, currently recorded under equity, will be allocated to plan holders in 2011 H1. In line with the long-term trend of low pension fund returns, it is not expected that the 2011 income will contribute to an increase in equity.

The total equity available to the funds is sufficient for the situation modelled by the *Baseline Scenario*. After the application of the *Asymmetric Developments* and *Renewed Recession* scenarios, which work with greater levels of stress, pension funds' equity would fall to very low levels and would not even be sufficient to cover the losses in the *Asymmetric Developments* case.

Estimate of the capitalisation of pension funds
(CZK billions)



Source: CNB, CNB calculation

Given the existing prudential mechanism agreed between the Association of Pension Funds and the CNB after the problems in 2007–2009, shareholders would have to increase the funds' capital in both stress scenarios – by CZK 11.5 billion in the *Renewed Recession* scenario and by CZK 8 billion in the *Asymmetric Developments* scenario.

The test results show that foreign exchange risk is the biggest risk to pension funds in the *Baseline Scenario*, as 14% of the sector's assets are allocated in foreign currency. Bond revaluation losses and losses on shares and units play the key role in the *Asymmetric Developments* and *Renewed Recession* scenarios. The risks arising from property price changes are negligible in both stress scenarios. However, the scenarios differ fundamentally in respect of exchange rate risk, as a depreciation of the koruna during the assumed *Renewed Recession* would lead to part of the losses being covered by an increase in the value of the foreign currency portfolio. In the *Asymmetric Developments* scenario, this effect will not arise and the overall outcome will be worse despite other smaller market risks.

Results of the pension fund stress tests

	Baseline Scenario	Asymmetric Developments	Renewed Recession
Equity (as of start of 2011)			
CZK billions	14.4	14.4	14.4
% of assets	6.2	6.2	6.2
Allocation of 2010 earnings for policyholders			
CZK billions	-3.9	-3.9	-3.9
% of assets	-1.7	-1.7	-1.7
Bond revaluation gains/losses			
CZK billions	-0.3	-8.0	-8.9
% of equity	-2.2	-55.7	-62.3
Gains/losses from changes in share and unit value			
CZK billions	-0.5	-2.1	-4.2
% of equity	-3.7	-14.7	-29.4
Exchange rate gains/losses			
CZK billions	-1.0	-2.2	4.2
% of equity	-6.7	-15.6	29.0
Gains/losses from changes in property value			
CZK billions	-0.1	-0.2	-0.4
% of equity	-0.4	-1.7	-2.6
Impact of risks on equity			
CZK billions	-1.9	-12.6	-9.4
% of assets	-0.8	-5.4	-4.0
Equity (as of end of 2011)			
CZK billions	8.6	-2.1	1.1
% of assets	3.7	-0.9	0.5

Source: CNB, CNB calculation

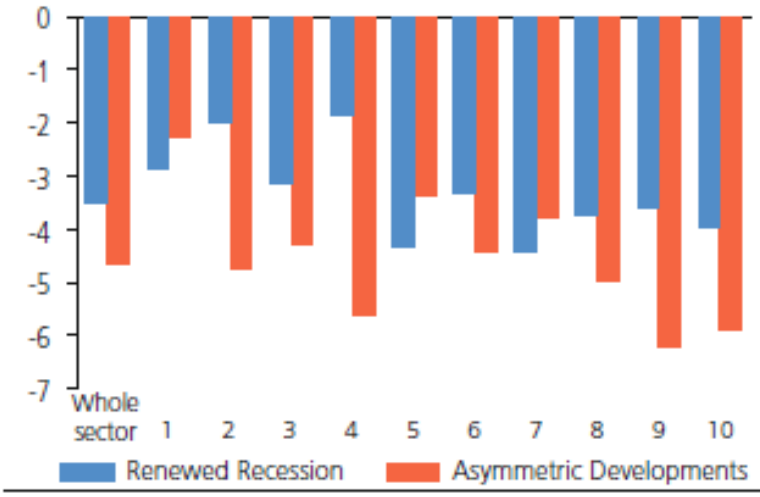
Ad hoc sensitivity analysis is also conducted to reveal the impact of regulatory risks and possible liquidity problems. The measure, initiated by the CNB allowing pension funds to classify part of the bonds in their portfolios as held to maturity, turns out to be a significant help for pension funds. If the funds experienced a liquidity crisis and were forced, under the conditions of the individual stress scenarios, to revalue this part of the portfolio in line with its current market value, their losses would rise by a further CZK 5–6 billion. In an ad-hoc sensitivity test, this assumption was extended to include the impact of regulatory risk. Given the insufficient preparedness of pension funds for the pension reform, we assumed a faster release of all deferred costs into the profit and loss account in 2011. The results of the extended test for individual pension funds show that owing to their similar investment profiles and balance sheet structures, all pension funds would have to top up their capital. Total capital injections would rise to CZK 20 billion in the least favourable *Asymmetric Developments* scenario. However, this is an extreme stress, assuming a simultaneous impact of all risk factors.

Ad-hoc sensitivity analysis in the pension fund tests
(additional shocks in individual scenarios)

	Baseline Scenario	Asymmetric Developments	Renewed Recession
Release of deferred costs in 2011			
CZK billions	-3.5	-3.5	-3.5
% of assets	-1.5	-1.5	-1.5
Revaluation of instruments held to maturity			
CZK billions	-0.2	-5.2	-5.7
% of assets	-0.1	-2.2	-2.4
Equity (as of end of 2011)			
CZK billions	4.9	-10.8	-8.1
% of assets	2.1	-4.7	-3.5

Source: CNB, CNB calculation

Capitalisation of individual funds after application of the stress scenarios, including the ad-hoc extension
(as % of total assets of fund; anonymised)



Source: CNB
Note: The figures for the individual funds 1–10 are ranked by resulting equity.

Germany[24]

Stress tests in Germany apply to insurance companies, including Pensionskassen which provide capital and other guarantees. In Germany, only DB pension schemes are permitted.

The supervisory authority has various, future-oriented tools at its disposal as an early warning system. One of these tools is the stress test, which assumes a possible, but uncertain development in the capital market. Stress tests have been added as an additional quantitative element to the reporting requirements for

[24] Material taken from Germany country case study in *IOPS Toolkit for Risk-based Supervision* www.iopstoolkit.org. See also BaFin website: http://www.bafin.de/EN/Supervision/InsuranceUndertakingsPensionFunds/-StressTest/stresstest_artikel.html

the risk management of investments. They simulate the impact of variations on the capital market on an insurer's balance sheet and are intended to prompt insurance undertakings to boost their risk-bearing capacity in good time if the results of the test are negative. The stress test shows whether or not the undertaking can meet its contractual obligations without taking countermeasures in a simulated crisis situation. Undertakings must also have a solid footing with a view to capital market crises arising in the future.

The current BaFin stress test provides for four scenarios:

- bonds only test: 10% decline in the price of fixed-income securities (credit risks taken into account);
- equities only test: decline in the price of equities against the relevant index level at 31 December (credit risks taken into account);
- bond and equity test: decline in the price of equities against the relevant index level at 31 December and 5% decline in the price of fixed-income securities (credit risks taken into account);
- equity and property test: decline in the price of equities against the relevant index level at 31 December and 10% decline in the market value of properties (credit risks taken into account);

The discounts applied to equities are shown in the following table:

EuroStoxx 50 (share price index)	Stress factor (single scenario) in %	Stress factor (mixed scenarios) in %
from 5246 to 5435 or above	45	25
from 5056 to 5245	45	25
from 4866 to 5055	45	25
from 4676 to 4865	45	25
from 4486 to 4675	44	24
from 4296 to 4485	41	22
from 4106 to 4295	38	21
from 3916 to 4105	35	20
from 3726 to 3915	32	19
from 3536 to 3725	29	18
from 3346 to 3535	27	17
from 3156 to 3345	24	16
from 2966 to 3155	22	15
from 2776 to 2965	20	14
from 2586 to 2775	18	13
from 2396 to 2585	16	12
from 2206 to 2395	14	12
from 2016 to 2205	13	11
from 1826 to 2015	11	11
up to 1825	10	10

Source: www.bafin.de.

The variations taken into account are based on the market environment on the day the stress test is carried out and, consequently, follow a rule-based approach. A result of "0" in the stress test means that, even in the event of an extreme crash, the investments are sufficient to cover the undertaking's obligations *vis-à-vis* the members and beneficiaries and do not endanger the solvency of the undertaking. A negative result, however, does not mean that fulfilment of the obligations is actually under threat.

Depending on the result of these scenarios, the company is subject to certain notification obligations towards BaFin. This rule-based process means that the discount applied increases as share prices rise so as to take into account the higher potential for prices to fall. Where prices have declined, the discount is reduced since the potential for a further decline is lower.

The minimum discount is 10%. The maximum discount in the equity only scenario is 45%, in a mixed scenario it is 25%. In addition, the following aspects should be noted:

- the bond and equity test assumes that prices on both the equity and bond markets decline at the same time;

- the equity and property test assumes that prices on both the equity and property markets decline at the same time;

- Section 341b of the Commercial Code (Handelsgesetzbuch – HGB) does not apply to equity portfolios.[25]

The BaFin stress test as at 31 December takes into account:

- reserves on the assets side of the balance sheet;

- buffers on the liabilities side (free RfB – provisions for bonuses and rebates – terminal bonus fund)

- capital operations;

- hedging operations.

Furthermore, features that are specific to the company in question, for example a shorter duration in the bond portfolio, can also be taken into account after the balance is calculated. This means that an undertaking can include valuation reserves contained in registered instruments, mortgages, loans, and other investments in stress tests in certain circumstances, and, under specific conditions, can take account of the fact that (part of) its equities are hedged.

If an undertaking does not pass the stress test taking into account its valuation reserves or hedging strategies, this does not mean that the undertaking is no longer in a position to meet its obligations *vis-à-vis* its policyholders at the present time. A negative stress test result is merely to be understood as a signal that the undertaking has a reduced risk-bearing capacity and that this must be rectified early on.

The following concrete measures can be considered in this respect:

[25] The Commercial Code (HGB) comprises provisions specifically applicable to insurance undertakings, inter alia on the valuation of investments (sections 341b to 341d HGB). The supervisory authority checks if these provisions are complied with in the course of both on-site and off-site inspections. As a basic principle, investments of insurance undertakings (stocks, investment trust units, and other fixed-income and variable-yield securities) had to be treated as current assets, which meant that even temporary losses in value to an amount below the acquisition price shown in the balance sheet had to be written down at the balance sheet date and thus to the detriment of the undertaking's profits (strict principle of lower-of-cost-or-market value). An exception to this is section 341b (2) HGB, whereby insurers may treat their investments as fixed assets if and to the extent they serve business operations on a permanent basis. Consequently, insurers are required to write down values only in the event of lasting depreciations (restricted principle of lower-of-cost-or-market value). This rule is in order to mitigate the effects of current capital market developments, i.e. to protect the securities markets from short-term effects as a result of high volatilities. The rule is, moreover, designed to create stability in an unstable and depressed stock market environment and to prevent resulting fluctuations in the policy-holders' profit-sharing benefits. The more detailed rules governing this exception are contained in an Auditors' Standard agreed with the supervisory authority. Furthermore, the supervisory authority requests insurers to report quarterly for not only book values but also the current values of investments to evaluate the financial stability of the insurers and its risk-bearing ability on the basis of current/market values of its investments.

- additional capital,
- investment reallocation,
- hedging of investments on the capital markets, and
- reduction in the surplus participation.

In supervisory terms, a failed stress test does not automatically trigger certain measures. Rather, decisions to increase a company's risk-bearing capacity require an individual assessment of the undertaking in question. In addition, companies have to carry out at least quarterly internal stress tests based on a BaFin set of minimum scenarios. Depending on the results, certain notification obligations have to be met. In the case of small entities, BaFin is entitled to alleviate the conduct of stress tests on an individual basis, based on the kind and volume of investments and the kind of business the Pensionskasse forms.

Israel

In Israel, long-term savings are divided between three vehicles: pension funds, provident funds, and life insurance policies. Stress tests are run for new products where the individual saver bears the investment risk, with the exposure to market risk being tested. The implementation of the stress test involves identifying the main sources of market risk for the three different types of product – i.e. equity, interest rate curve, spreads, inflation, and foreign exchange depreciation. The investment portfolios of the different savings vehicles are segmented into the main asset classes, namely equity, government bonds, deposits, loans, corporate bonds, and overseas investments. Changes in risk factors according to various scenarios are then applied to the portfolio (i.e. an endogenous shock vs. an exogenous shock to the Israeli market). The scenarios used are as follows:

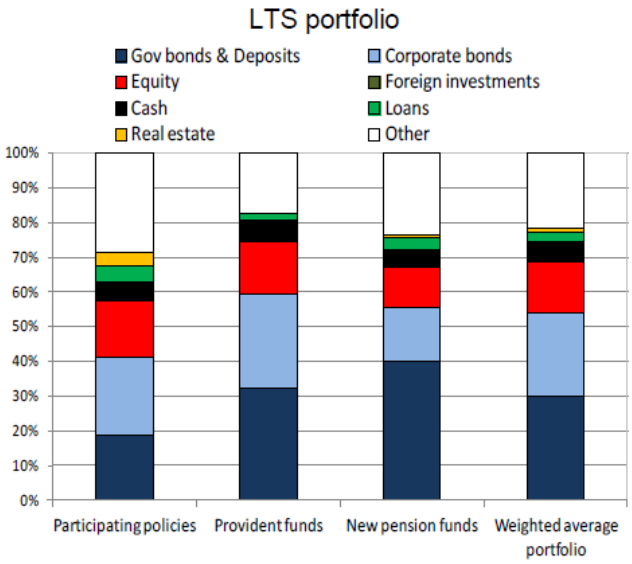
Risk factor	Stress Test
Risk-free rate	–20%
	+20%
Spread	+50 basis points
	+100 basis points
	+200 basis points
Equity market	–20%
	–30%
Foreign exchange rate	–20%
	+20%

Source: Israel Ministry of Finance.

In 2012, the IMF produced a technical note on the Israeli stress tests run for the banking, insurance and pension sectors.[26] This explains that three macro-scenarios were used – a base case and two shock scenarios (adverse scenario 1 representing a large domestic shock and adverse scenario 2 representing a serious international and domestic shock). The macro-scenarios include projections of GDP, inflation, interest rates, equity prices, and several bond prices. Single-factor tests were conducted to estimate vulnerabilities to market risk (interest rate, exchange rate, and stock market shocks). Insurance and pension fund stress tests were carried out to differentiate between different types of liabilities, depending on whether insurance companies or policy holders bore the risks. The tests were largely based on previous analysis, including the Quantitative Impact Study (QIS) 5 exercise.

The IMF report concludes that the results of the shocks on long-term savings products show manageable effects. Market shocks of a similar magnitude as those occurring during the 4th quarter of 2008 and simulated scenario of a severe local shock were seen to result in a 7.7% decline in long-term savings (partly as equity holdings are only around 20% of the average long-term savings portfolio). This implies that the stop-loss 50% decline, government guarantee for pensions close to retirement is unlikely to be activated. Indeed, the main risks noted by the IMF were less market-based and more operational and legal risks.

Figure 7. Israel: Long Term Savings (LTS) Stress Test Results



LTS in local and foreign investments
(In percent)

	Local investments	Foreign investments
Participating policies	79.4	20.6
Provident funds	88.2	11.8
New pension funds	82.1	17.9
Weighted average portfolio	84.8	15.2

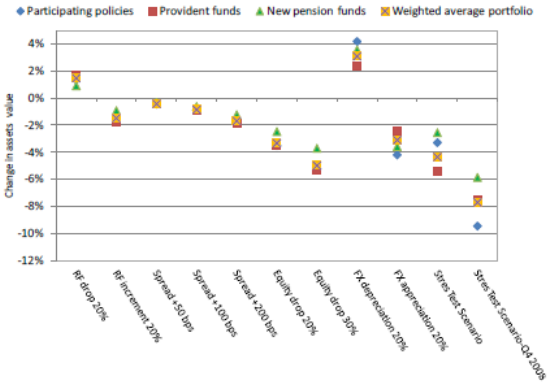
Source: CMISD (IMF, 2012).

[26] See IMF (2012), 'Israel: Technical Note on Stress Test of the Banking, Insurance and Pension Sectors', IMF Country Report No. 12/88, http://www.imf.org/external/pubs/ft/scr/2012/cr1288.pdf

Figure 7 (Continued). Israel: Long Term Savings Stress Test Results
(Change in value of LTS, in percent)

Scenario / Segment	RF drop 20%	RF increment 20%	Spread +50 bps	Spread +100 bps	Spread +200 bps	Equity drop 20%	Equity drop 30%	FX depreciation 20%	FX appreciation 20%	Stress test scenario	Stress test scenario-Q4 2008
Participating policies	1.4	-1.4	-0.4	-0.9	-1.8	-3.5	-5.2	4.2	-4.2	-3.3	-9.4
Provident funds	1.7	-1.7	-0.5	-0.9	-1.8	-3.5	-5.3	2.4	-2.4	-5.4	-7.5
New pension funds	0.9	-0.9	-0.3	-0.6	-1.2	-2.5	-3.7	3.6	-3.6	-2.5	-5.8
Weighted average portfolio	1.5	-1.5	-0.4	-0.8	-1.7	-3.3	-5.0	3.1	-3.1	-4.3	-7.7

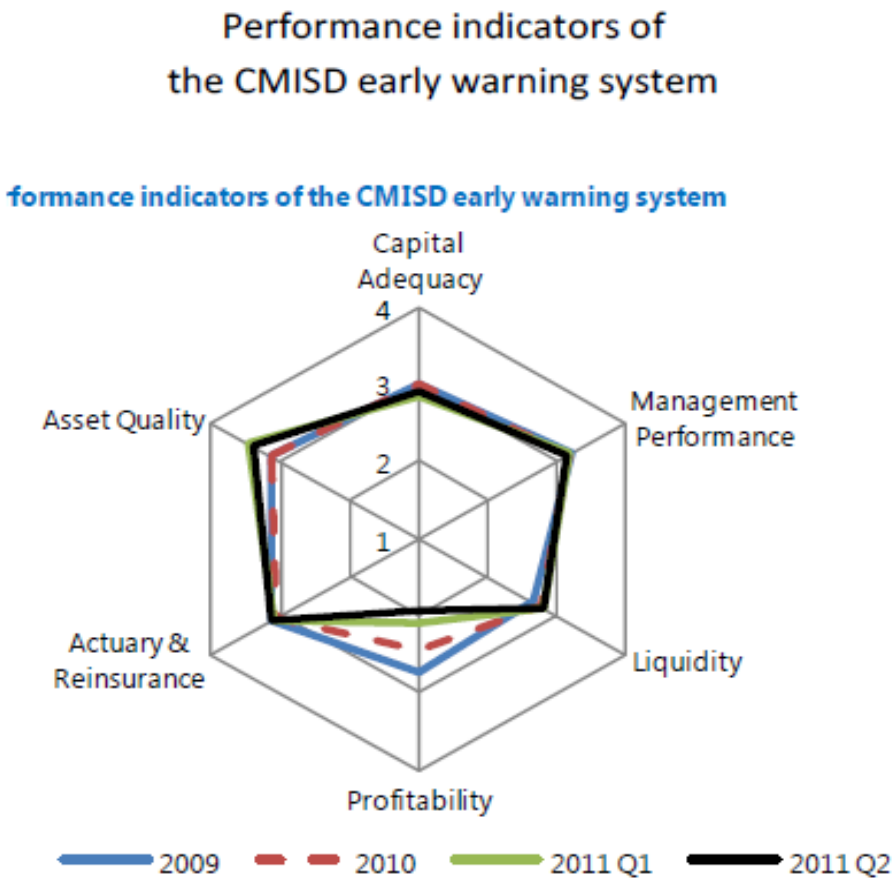
Scenario results										Local Shock Stress Test Scenario				Stress Test Scenario-Q4 2008						
	RF drop 20%	RF increment 20%	Spread +50 bps	Spread +100 bps	Spread +200 bps	Equity drop 20%	Equity drop 30%	FX gain 20%	FX loss 20%	Risk free interesrt	Spread	Equity	FX	Equity	Gov bonds	Corporate bonds	Loans	Cash	Deposits	Foreign investments
										-20%	+200 bps	-30%	-20%	-29.8%	4.6%	-9.4%	-4.4%	0.8%	4.6%	-15.0%
Participating policies	1.4	-1.4	-0.4	-0.9	-1.8	-3.5	-5.2	4.2	-4.2		-3.3						-9.4			
Provident funds	1.7	-1.7	-0.5	-0.9	-1.8	-3.5	-5.3	2.4	-2.4		-5.4						-7.5			
New pension funds	0.9	-0.9	-0.3	-0.6	-1.2	-2.5	-3.7	3.6	-3.6		-2.5						-5.8			
Weighted average portfolio	1.5	-1.5	-0.4	-0.8	-1.7	-3.3	-5.0	3.1	-3.1		-4.3						-7.7			



Source: Israeli authorities, and staff estimates.

Though the life insurance industry was hit hard by the 2008 financial crisis, the early warning system used by the supervisory authority (CMISD), which is based on 47 financial ratios combined into six parameters, shows it has subsequently recovered. The CMISD also measures market perception on the insurance sector (using the Merton model to assess the distance to default of traded insurance holding companies), which is also said to indicate that the industry has returned to pre-crisis levels.

The IMF report did, however, also conclude that stress tests run by companies for internal risk analysis need to be more stringent.



Source: CMISD (IMF, 2012).

Norway

The stress test scenarios cover all aspects of insurers'/pension funds' activity, including market risk (regarding both assets and liabilities), insurance risk, counterparty risk, and operational risk.

Stress test scenarios for market risk

- specified relative change in the yield curves both for interest rate increases and decreases, where the relative change decreases with lengthening maturity (see table below) – the potential loss associated with interest rate risk involves calculating the fair value of the liabilities;
- – 39% equity markets for type 1 shares (listed shares in the EEA or OECD area) and 49% for type 2 shares (other equity exposure) – the shocks are adjusted by a symmetric adjustment mechanism within a band of plus or minus 10%.
- – 25% in property markets;
- +/– 25% in the foreign currency exchange rate;

- specified changes in credit spreads based on rating class;
- concentration risk resulting from significant exposure to a single counterparty.

Relative change in the interest rate curve under varying duration

Duration (years)	0,25	0,5	1	2	3		19	20		30+
Relative change s_{up}	0,70	0,70	0,70	0,70	0,64	.....	0,27	0,26	.....	0,25
Relative change s_{dwn}	-0,75	-0,75	-0,75	-0,65	-0,56		-0,29	-0,29		-0,30

Stress test scenarios for insurance risk

- mortality risk: + 15% in the force of mortality;
- longevity risk: – 10% in the force of mortality;
- disability risk: + 25% in the force of disability the first year and +15% the subsequent years;

Aggregated potential loss (*S*) is defined as:

$$S = \sqrt{\sum_{r,k} Korr_{r,k} \cdot T_r \cdot T_k} \ ,$$

where

$Korr_{r,k}$ = correlation matrix given below and where *r* and *k* indicates row and column.

T_i = estimated potential loss for risk category "*i*":

Corr	Market risk	Insurance risk Life	Non-life risk Applicable for Life insurance	Counterparty risk
Market risk	1	0,25	0,25	0,25
Insurance risk Life	0,25	1	0	0,5
Non-life risk Applicable for Life insurance	0,25	0	1	0,5
Counterparty risk	0,25	0,25	0,5	1

Potential loss for each subcategory (market risk, life insurance risk, non-life applicable for life insurance risk, counterparty risk) is aggregated in a similar manner.

The stress tests measure the companies' overall risk against buffer capital, i.e. their buffer capital utilization. Buffer capital utilization above 100% indicates that the solvency capital requirement under Solvency II is not met.

Early warning analysis

The variables used in the early warning ranking of pension funds are equity percentage, capital adequacy, and buffer capital (sum of surplus tier 1 capital, fluctuation reserves, and supplementary provisions).

Name	Eqity component	% better	Capital adequacy	% better	Buffer*	% better	Sum	Rank	Total assets	Private/Municipal
Pension fund A	**43,6 %**	**97**	**7,5 %**	**100**	**2,6 %**	**99**	**296**	**1**	**7**	
Pension fund B	**40,9 %**	**93**	**11,6 %**	**94**	**3,3 %**	**94**	**282**	**2**	**301**	
Pension fund C	38,3 %	87	11,1 %	96	7,7 %	60	242	3	9 852	M
Pension fund D	31,0 %	69	12,8 %	81	5,0 %	88	237	4	3 128	M
Pension fund E	32,1 %	71	12,3 %	85	5,9 %	79	235	5	152	
Pension fund F	25,7 %	48	12,0 %	90	3,0 %	96	234	6	83	M
Pension fund G	25,9 %	49	10,9 %	97	5,5 %	82	228	7	2 353	
Pension fund H	31,0 %	70	13,3 %	74	5,6 %	81	225	8	482	
Pension fund I	36,7 %	84	13,0 %	79	7,5 %	61	224	9	603	
Pension fund J	30,1 %	65	13,2 %	75	5,4 %	83	224	9	1 450	M

The results of the EW analysis are used to evaluate the risk of breaches of solvency requirements. Measures towards identified pension funds can be ad hoc reporting of their solvency position, ad hoc reporting of stress tests or on-site inspection. Other factors used to identify candidates for inspection are size, time since last inspection, and quality of the reported figures/analyses.

APPENDIX V. INSURANCE TEST MATRIX FOR LONG TERM SAVINGS PROVIDERS

Domain	Element	Assumptions for Top Down Stress Tests
Institutions	Life insurers, pension funds and provident funds	• The whole market of long term savings is included, differentiated by type of provider.
Market share	Assets, reserves, premia	• 100 percent of the market • NIS 140 billion insurance providers • NIS 300 billion, provident funds • NIS 95 billion, new pension funds
Data	Source	• Regulatory data as of June 2011
Methodology	supervisory models	• Immediate shock on the value of the portfolio
Stress test horizon	Duration	• Immediate shock on the value of the portfolio

Shocks	Scenario analysis
	Single factor shocks
		• Historic based scenario: 4th Quarter 2008
		  • Foreign investments -15 percent
		  • Loans -4.4 percent
		  • Corporate bonds -9.4 percent
		  • Government bonds and deposits 4.6 percent
		  • Equity -29.8 percent
		• Simulated local shock scenario:
		  • FX depreciation -20 percent
		  • Corporate spread 200 bp
		  • Risk free interest + 20 percent
		  • Equity -30 percent

Risk factors	(e.g., equity prices, yield curve, production, lapses, etc.).	• (See above)
Behavioral adjustments	Managerial and policyholders' reactions (none for one-year horizon)	• None
Regulatory standards	Definition of solvency (risk-sensitive regime is necessary)	• No capital impact since focus on depreciation of portfolio value
	Accounting requirements (mark-to-market valuation is preferable)	• Mark to market valuation

Results	Asset losses	• Historic based scenario: 4th Quarter 2008
		  • 9.45 percent loss in LTS provided by insurers
		  • 7.47 percent loss in LTS provided by provident funds
		  • 5.58 percent loss in LTS provided by pension funds
		  • Weighted average 7.70 percent loss
		• Simulated local shock scenario:
		  • 3.28 percent loss in LTS provided by insurers
		  • 5.43 percent loss in LTS provided by provident funds
		  • 2.55 percent loss in LTS provided by pension funds
		  • Weighted average 4.43 percent loss