Norges Bank Investment Management

Stress testing

Standard risk measures, such as volatility of returns, may not fully capture the potential impact of extreme events. Norges Bank Investment Management therefore supplements such measures with stress testing as a part of the investment risk framework. Stress tests aim to quantify potential losses in highly adverse scenarios in order to evaluate the portfolio's resilience. The fund conducts multiple forms of stress testing including historical stress testing and hypothetical, also known as predictive, stress testing. Historical stress testing uses changes in drivers of market risk such as equity prices, interest rates and real estate prices during historically stressed periods applied to the current portfolio to evaluate the impact of these events on the value of the fund. As a part of historical stress testing, we compute expected shortfall, which measures average loss of the portfolio in the worst q percent of outcomes. Hypothetical stress testing supplements subjective views with historical data to define shocks to a core set of systematic risk factors for a given scenario and map these risk factors to the current portfolio holdings to calculate the impact on the fund.

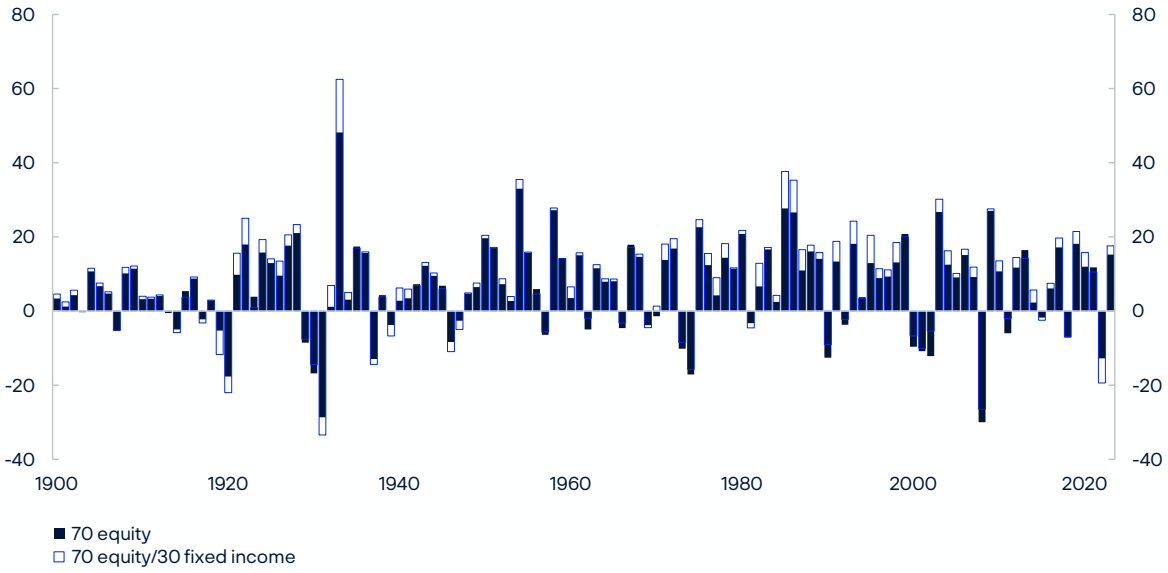
Historical stress tests

This section shows returns from historically stressed periods for the current asset composition of the fund. The section starts with an analysis of a stylised version of the fund's portfolio of global equities and bonds for a long historical sample. Then, historical simulations for the fund's positions at the end of 2024 are presented, using a model that covers all current investments. The section both includes simulated returns for specific historical scenarios as well as expected shortfall for various confidence levels.

Long historical sample

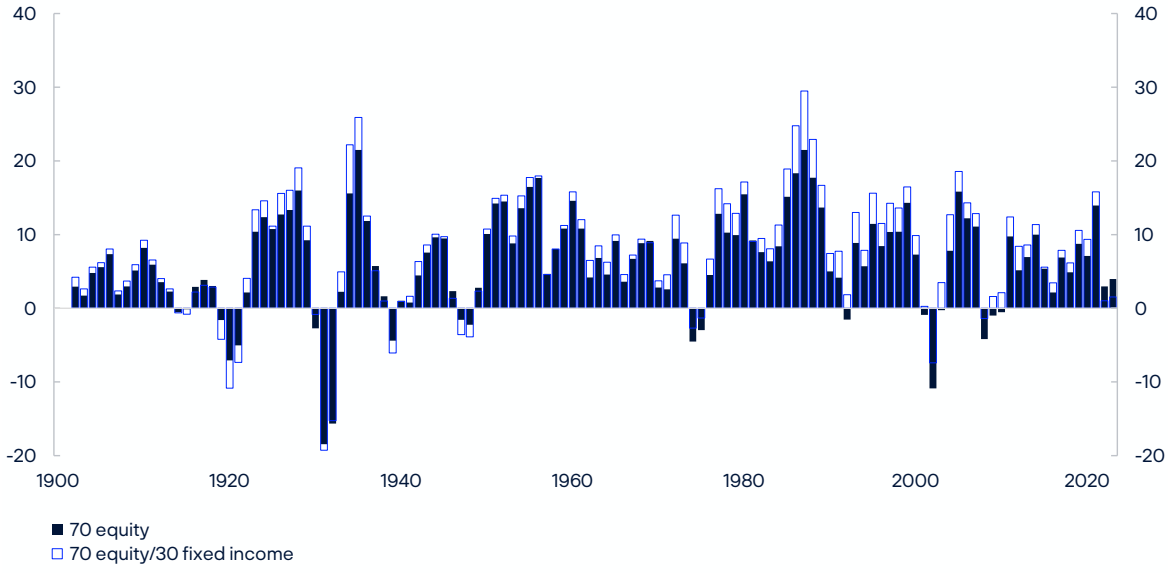
Chart 1-4 show rolling annualized returns over one, three, five and ten-year periods for a hypothetical portfolio made up of a fixed allocation of 70 percent equities and 30 percent fixed income. The returns are measured in US dollars and go back to 1900, covering more than 100 years of annual returns.

Chart 1 Annual return of 70 equity/30 fixed income. Measured in dollars. Percent.



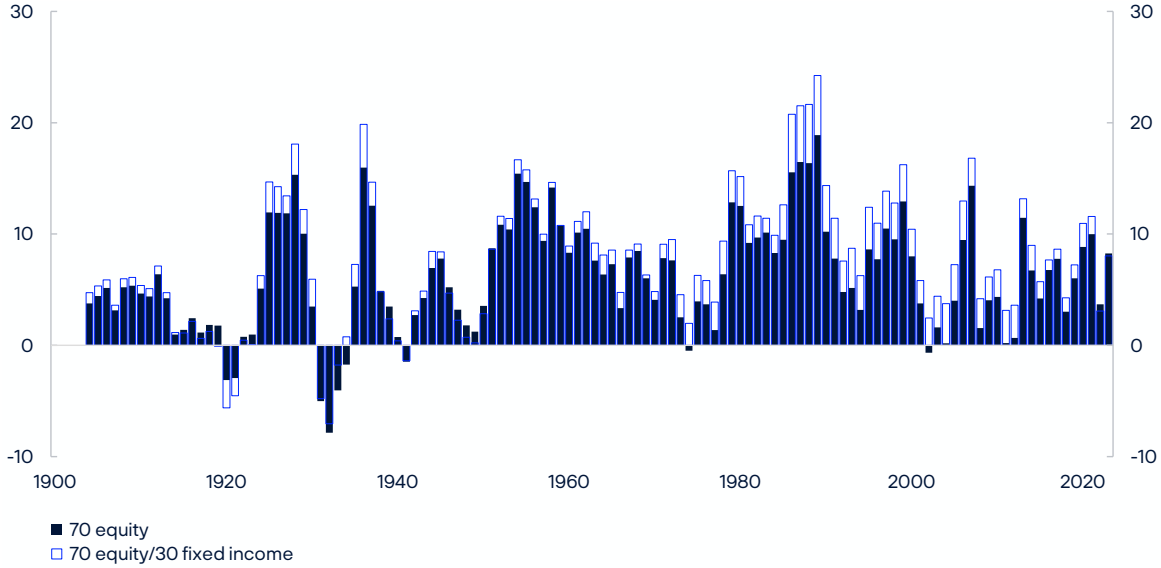
Source: Dimson-Marsh-Staunton global return data

Chart 2 Annualised 3-year rolling return of 70 equity/30 fixed income. Measured in dollars. Percent.



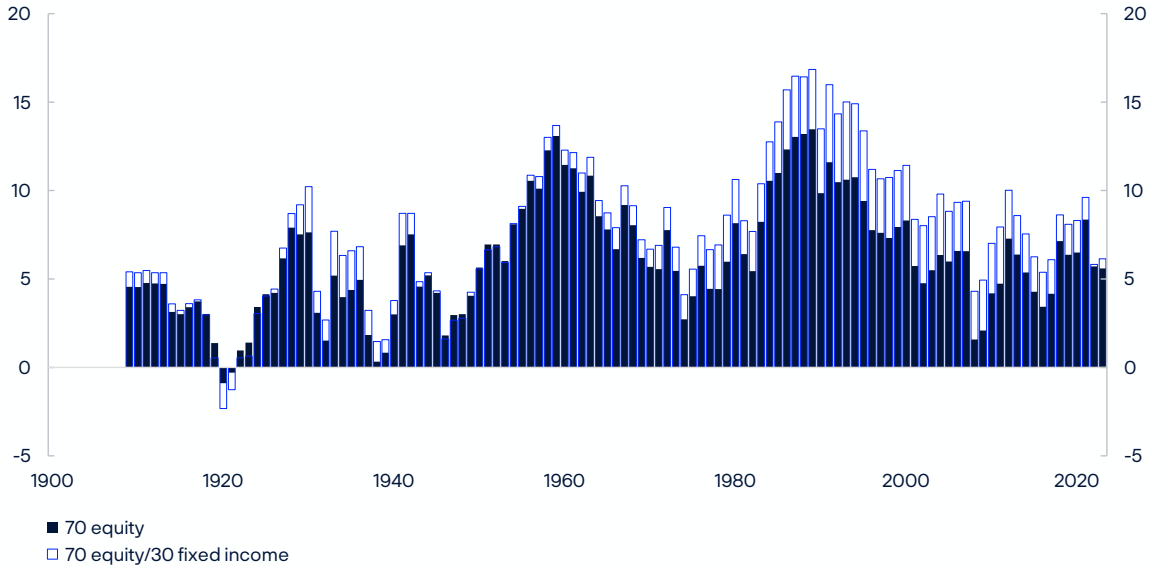
Source: Dimson-Marsh-Staunton global return data

Chart 3 Annualised 5-year rolling return of 70 equity/30 fixed income. Measured in dollars. Percent.



Source: Dimson-Marsh-Staunton global return data

Chart 4 Annualised 10-year rolling return of 70 equity/30 fixed income. Measured in dollars. Percent.



Source: Dimson-Marsh-Staunton global return data

Historical scenarios

Table 1 shows simulated portfolio returns for a selection of widely reported on events since May 1997. Results are shown both for the fund as well as equity and fixed-income management.

Table 1 Historical simulations of event returns for the fund, equity management and fixed-income management as at 31 December 2024, measured in the currency basket. Returns in percent of entity NAV.

Event	First date	Last date	Numbers of months	Fund	Equity manage-ment	Fixed income manage-ment
Asian financial crisis	07.01.1997	12.31.1997	6	9.2%	11.2%	3.4%
Russian default	08.01.1998	09.30.1998	2	-7.7%	-12.5%	4.0%
Dot com crash 1	09.01.2000	03.31.2001	7	-8.4%	-13.2%	3.3%
9/11	09.01.2001	09.30.2001	1	-8.7%	-12.6%	0.6%
Dot com crash 2	01.01.2002	09.30.2002	9	-12.3%	-19.8%	5.5%
Global Financial Crisis	05.01.2008	02.28.2009	10	-30.1%	-40.9%	-0.3%
Euro debt crisis	04.01.2011	11.30.2011	8	-4.1%	-7.5%	4.5%
Taper Tantrum	05.01.2013	08.31.2013	4	3.9%	7.4%	-4.1%
Oil price decline	07.01.2014	12.31.2014	6	6.0%	7.5%	1.7%
EM slowdown	06.01.2015	09.30.2015	4	-5.7%	-8.2%	0.3%
Brexit referendum	06.01.2016	06.30.2016	1	-0.4%	-1.3%	1.7%
Volatility spike	09.01.2018	12.31.2018	4	-9.5%	-13.2%	-0.2%
Covid pandemic	02.01.2020	03.31.2020	2	-13.2%	-18.2%	0.2%
DM rate hike	01.01.2022	09.30.2022	9	-19.1%	-20.6%	-14.5%

Absolute expected shortfall

Chart 5 to 8 show the fund's expected shortfall for multiple tail probabilities using weekly historical simulations since January 2007. The chart also shows sensitivity to the choice of reporting currency. Whereas the Norwegian kroner depreciated in several past crises, other currencies appreciated. This analysis highlights how a stressed scenario where the Norwegian krone does not depreciate increases expected tail risk.

Chart 5 Expected shortfall of actual portfolio as at 31 December 2024. Confidence level 90%. Percent.

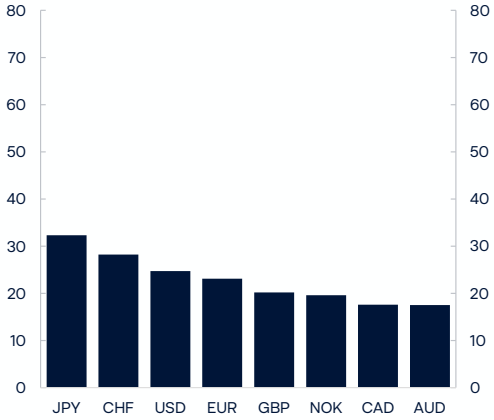


Chart 6 Expected shortfall of actual portfolio as at 31 December 2024. Confidence level 95%. Percent.

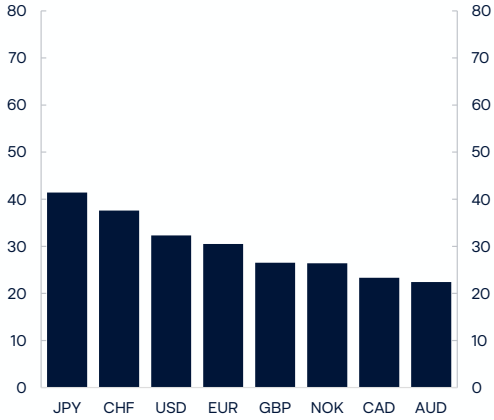


Chart 7 Expected shortfall of actual portfolio as at 31 December 2024. Confidence level 97.5%. Percent.

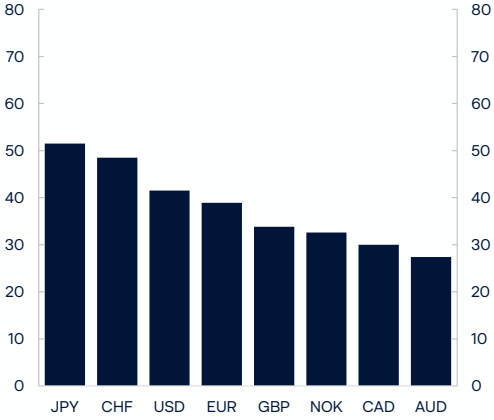
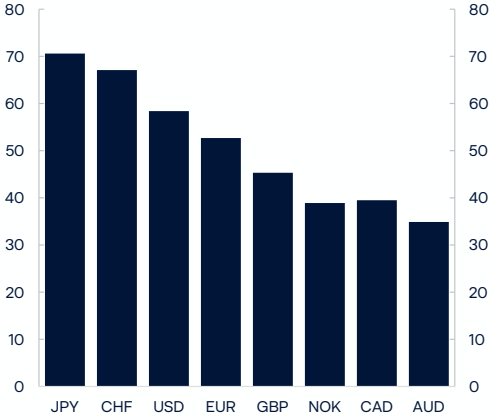


Chart 8 Expected shortfall of actual portfolio as at 31 December 2024. Confidence level 99%. Percent.



Hypothetical stress tests: Systematic risk factors

An important drawback of historical simulations is that future crises may play out differently than in the past. To explore the performance of the fund's portfolio under a range of adverse scenarios, Norges Bank Investment Management performs scenario-based forward-looking stress tests. Our stress tests are designed to capture extreme market outcomes over a horizon of up to five years.

The selection of scenarios is informed by key topics that have the potential to shape the macro environment over the next years. We model three relevant risks, chosen from a longer list of stressed events that could have a large adverse impact on the fund's portfolio. We identify the risks by considering both their probability of occurring and severity. The list of three scenarios therefore evolves from year to year and is shaped by changing world affairs, economic conditions, and movements in asset prices.

Given that we are explicitly looking at stressed events, only reasonably high-impact scenarios will make the list, and such scenarios, by definition, have a relatively low likelihood of occurring. Because we consider both probability and impact, there will be some scenarios with catastrophic impact but very low probability, and vice versa, that do not make the list.

In last year's stress test, we considered the following scenarios: debt crisis, repricing of risk and divided world. None of the scenarios have materialised. This is not surprising given that all three scenarios refer to extreme outcomes that have a relatively low probability of occurring, especially over shorter horizons. However, it is still useful to discuss them in retrospect.

During 2024, central banks in advanced economies started reducing interest rates as inflation came down towards the two percent target. Economic growth in major economies has remained stable, although Europe continues to trail behind the United States. Globally, debt levels remain elevated and there is no sign of a return to fiscal discipline. Most equity markets soared in 2024, and a repricing of risk has yet to materialise, with risk premia staying at historically low levels. Geopolitical tensions are on the rise worldwide, but a significant escalation between major economies has not occurred. The combination of high debt levels, low risk premia and rising geopolitical tensions creates conditions conducive for stress testing asset prices.

Looking at a combination of likelihood and potential portfolio impact, we consider three relevant risks to be "AI correction", "Debt crisis" and "Fragmented world". We discuss each in more detail below.

AI correction

The rapid rise in AI-related company valuations has been driven by high expectations for future earnings growth. If the AI investments fail to generate profits due to adverse conditions such as regulatory interventions, technological setbacks, or supply scarcity, growth expectations could revert to levels seen before the AI boom. This would lead to a permanent downward shift in expected cash flows and an increase in the equity risk premium, while the term premium decrease due to an increase in investor demand for government bonds. Compared to last year's repricing of risk scenario, we specifically focus on the market concentration in AI stocks.

Debt crisis
Ageing populations, climate change, international conflicts, and less fiscally responsible governments put a strain on already elevated debt levels. A lack of funding and political uncertainty trigger a bond sell-off as investor confidence evaporates. This shifts up the yield curve, with term and liquidity premium increasing across the maturity spectrum. It will also have negative spillovers to the corporate bond market and financial intermediaries. In turn, higher mortgage rates and tightened lending standards dampen consumption and investment, resulting in lower economic growth and lower expected cash flows. Political uncertainty will also result in an increase in the equity risk premium.

Fragmented world
The world fragments into multiple distinct economic blocks. The challenging geopolitical environment leads to higher tariffs, increased regulations, restrictions on foreign investment, and less fiscal discipline. The impact on developing economies is more severe in this scenario than in the other two scenarios. The uncertainty and reduced economic cooperation results in lower global growth and increased market volatility. Expected cash flows are shifted downward permanently. More near-shoring and friend-shoring leads to higher inflation in all major economies.

The three scenarios we have considered are designed to be complementary rather than overlapping, although they feature certain commonalities in their underlying macro-economic shocks. In reality, multiple scenarios tend to play out at once. For example, geopolitical tensions in the fragmented world could affect investor confidence as described in the debt crisis scenario.

To estimate the portfolio impact under the three scenarios outlined above, we translate the narratives into shifts in the following return drivers for equities and fixed income: dividend growth, equity risk premium, inflation expectations, real rates, term premium and liquidity premium. Our starting point for creating scenarios is the current market pricing for each return driver. Each scenario is created through a particular combination of shifts in these drivers. These shifts are informed by a combination of relevant historical episodes, auxiliary models and economic intuition, with the goal of ensuring economic consistency. Next, we estimate the exposures of each asset class to the return drivers listed above. We then combine shifts in return drivers with the estimated exposures to obtain the portfolio impact for each asset class.

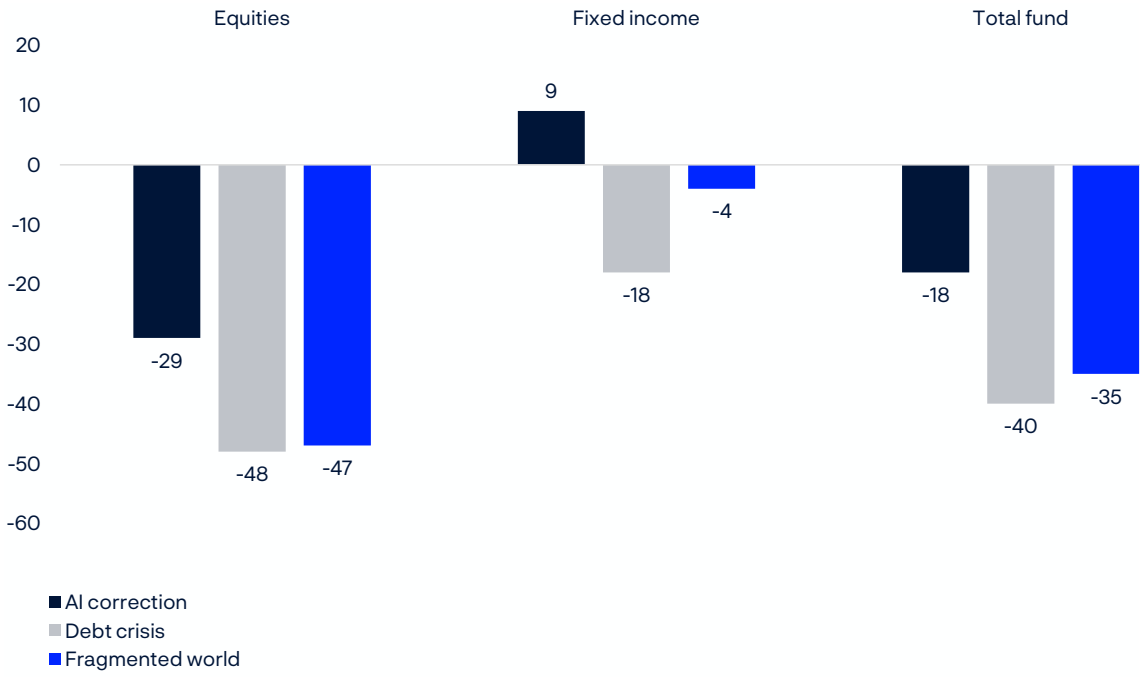
The aggregate portfolio impacts are shown in chart 9 and represent the change in portfolio value over a horizon of up to five years. Drawdowns could be more or less severe in the short run. Our three key takeaways are:

1) A dangerous mix: The probability of extreme market events has arguably risen compared to previous years. We are currently seeing a concerning combination of high global debt levels, escalating geopolitical tensions and high equity valuations.

2) Severe potential losses from geopolitical risk: “Fragmented world” would result in higher inflation and lower growth with both developed and emerging market equities facing significant losses. The total portfolio drawdown is estimated at 35 percent.

3) Loss of confidence could trigger a bond sell-off: Historically, bonds have provided a hedge to equity drawdowns, with the interest rate hikes of 2022 being an exception. With a loss of investor confidence in government bonds, the "Debt crisis" scenario could lead to another major bond sell-off. Combined with a significant loss on equities, we estimate the total fund drawdown at around 40 percent.

Chart 9 Hypothetical scenario impact for GPFG as at 31 December 2024, measured in local currency. Percent.



Among our scenarios, the "Debt crisis" results in the largest total fund drawdown. Historically, a 40 percent drawdown on a portfolio like the fund's would be a very severe and rare outcome. At the same time, larger losses are possible. The estimated impact is slightly higher than the one estimated in last year report because our current scenario is centred around a widespread loss in investors' confidence. Similarly, the portfolio impact of the "Fragmented world" scenario is larger than the impact of the "Divided world" scenario modelled last year. This is because last year's scenario was based on two major economic blocks, while this year we focus on widespread geopolitical tensions across multiple regions. The "AI correction" scenario results in a slightly smaller impact than the "Repricing of risk" scenario of 2023, due to its specific focus on the market concentration in AI stocks.

It should be noted that these scenarios may also materialise simultaneously, potentially leading to more severe drawdowns than modelled individually. For example, while we model "AI correction" in isolation, such a correction could also be triggered by a geopolitical conflict or a "fragmented" world. In such a case, the total fund drawdown would likely exceed the impacts shown here for each separate scenario.

In Table 2 we provide more details on the impacts by breaking down each asset class into its respective segments. In general, the largest losses come from equities, which are especially vulnerable in the current environment with low-risk premiums and high concentration. We see differences across scenarios in fixed income impact. AI correction leads to a flight to safety whereas debt crisis leads to large losses for bond investors. The scenarios are intentionally centred on our largest exposures in developed markets. However, in the fragmented world scenario, we also see large losses in emerging market equities.

Table 2 Hypothetical scenario impact for GPFG portfolio as at 31 December 2024.

	Exposure	Shock			Impact		
	Billions of kroner	Percent			Billions of kroner		
	Market Value	AI Correction	Debt Crisis	Fragmented World	AI Correction	Debt Crisis	Fragmented World
Equities in local currency							
Developed markets – small cap	1,041	-35	-55	-54	-360	-571	-558
Developed markets – large cap	11,194	-31	-49	-47	-3,426	-5,433	-5,306
Emerging and Frontier markets	1,499	-15	-38	-41	-217	-565	-614
Total in local currency	**13,735**	**-29**	**-48**	**-47**	**-4,004**	**-6,570**	**-6,478**
Fixed income in local currency							
Developed markets – short term treasuries	958	1	0	0	9	1	-5
Developed markets – long term treasuries	2,352	12	-25	-5	284	-592	-112
Developed markets – government related	493	11	-21	-5	56	-105	-23
Developed markets – corporates	1,561	10	-17	-6	158	-266	-91
Emerging markets	96	2	-5	-1	2	-5	-1
Total in local currency	**5,460**	**9**	**-18**	**-4**	**510**	**-968**	**-232**
Real Assets in local currency							
Listed real estate	356	-12	-66	-43	-41	-234	-153
Unlisted real estate	395	-4	-30	-19	-15	-119	-74
Unlisted infrastructure	48	2	-11	-2	1	-5	-1
Total in local currency	**800**	**-7**	**-45**	**-28**	**-56**	**-358**	**-228**
Total in local currency	**19,755**	**-18**	**-40**	**-35**	**-3,550**	**-7,895**	**-6,938**

Notes: Small cap and large cap are based on benchmark definitions. Long term treasuries include maturities of 3 years or more. Corporates include securitized bonds. Unlisted real estate shows gross asset value for exposure and listed real estate only includes equity exposure. Derivatives are mapped to the relevant asset class. The totals include Cash and FX.

Relative expected shortfall

The Executive Board has set a mandate limit for expected stressed relative loss versus the fund's benchmark index. The fund is to be managed in such a way that the annual expected shortfall does not exceed 3.75 percentage points. Table 3 shows relative expected shortfall for the fund as well as each of the fund's investment strategies.

Table 3 Expected shortfall relative to benchmark of investment strategies as at 31 December 2024. Each strategy measured stand-alone with the other strategies positioned in-line with the benchmarks. All numbers measured at fund level in the fund's currency basket. Basis points.

	Expected shortfall price history since 01.01.2007
Market exposure	23
Asset positioning	23
Security selection	43
Internal security selection	42
External security selection	22
Fund allocation	114
Real estate	108
Unlisted real estate	44
Listed real estate	78
Renewable energy infrastructure	6
Allocations	38
Total	**118**