

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.

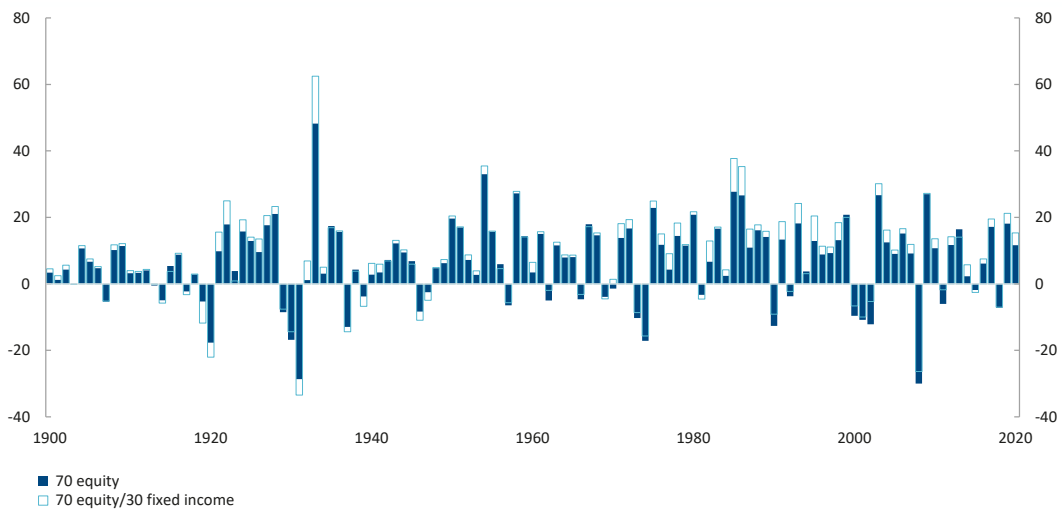
Historical stress tests

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 2021 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

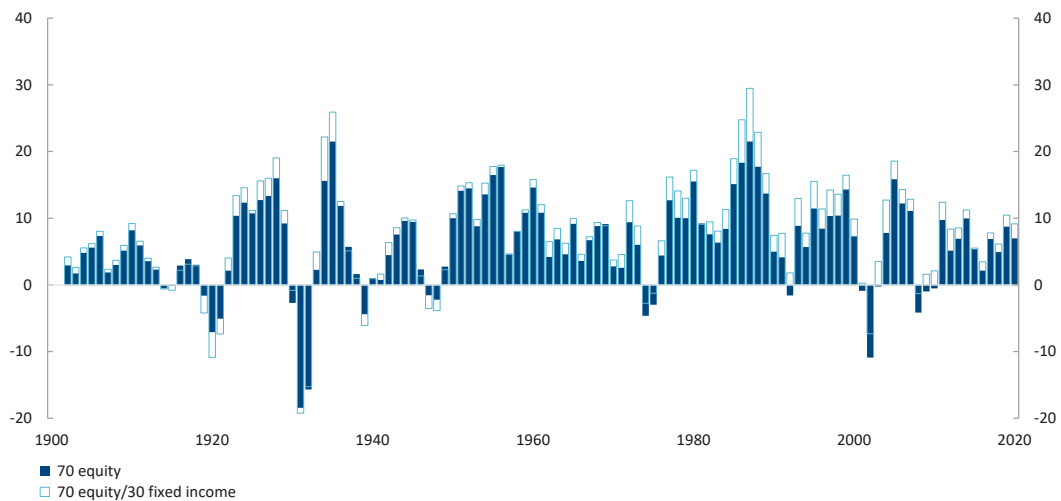
Figure 1-4 show rolling annualized returns over one, three, five and ten-year periods for a hypothetical portfolio made up of a fixed allocation of 70 percent equities and 30 percent fixed income. The returns are measured in US dollars and go back to 1900, covering more than 100 years of annual returns.

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



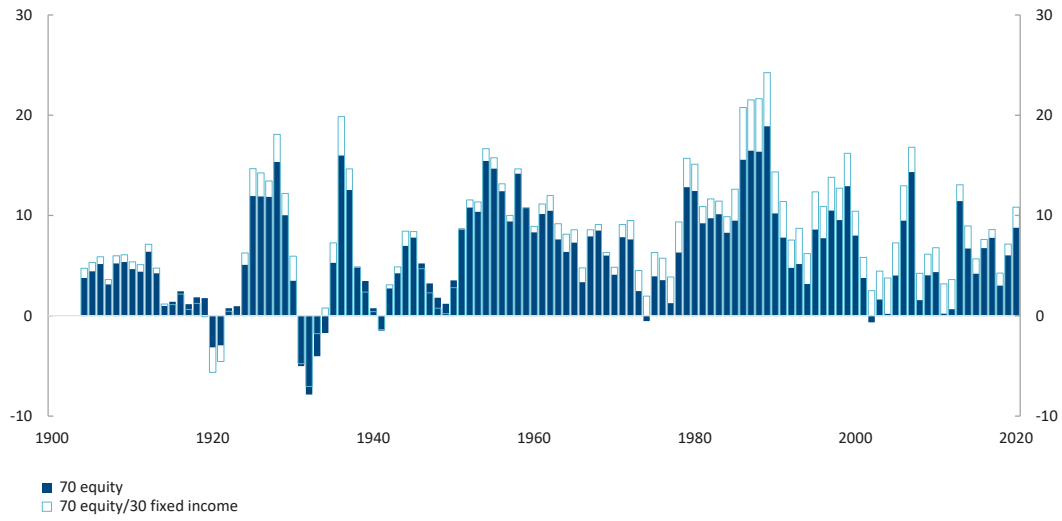
Source: Dimson-Marsh-Staunton global return data

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



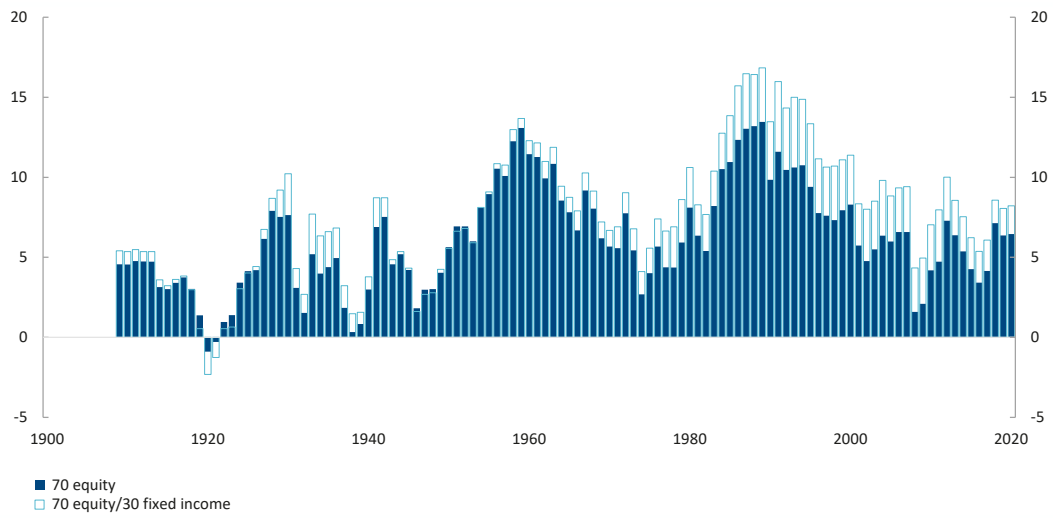
Source: Dimson-Marsh-Staunton global return data

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 2021, measured in the currency basket. Returns in percent of entity NAV.

Event	First date	Last date	Numbers of months	Fund	Equity management	Fixed income management
Asian financial crisis	01.07.1997	31.12.1997	6	7.06 %	7.93 %	3.60 %
Russian default	01.08.1998	30.09.1998	2	-8.52 %	-13.36 %	3.72 %
Dot com crash 1	01.09.2000	31.03.2001	7	-7.33 %	-11.97 %	3.04 %
9/11	01.09.2001	30.09.2001	1	-8.59 %	-12.16 %	0.35 %
Dot com crash 2	01.01.2002	30.09.2002	9	-11.96 %	-18.64 %	4.54 %
Global Financial Crisis	01.05.2008	28.02.2009	10	-31.36 %	-41.39 %	0.16 %
Euro debt crisis	01.04.2011	30.11.2011	8	-4.94 %	-8.64 %	4.89 %
Taper Tantrum	01.05.2013	31.08.2013	4	3.70 %	6.94 %	-4.40 %
Oil price decline	01.07.2014	31.12.2014	6	5.56 %	6.31 %	2.68 %
EM slowdown	01.06.2015	30.09.2015	4	-6.62 %	-9.55 %	0.10 %
Brexit referendum	01.06.2016	30.06.2016	1	-0.42 %	-1.27 %	1.92 %
Volatility spike	01.09.2018	31.12.2018	4	-9.21 %	-12.35 %	-0.40 %
Covid pandemic	01.02.2020	31.03.2020	2	-14.18 %	-18.72 %	-0.40 %

Absolute expected shortfall

Charts 5 to 8 show the fund's expected shortfall for multiple tail probabilities using weekly historical simulations since January 2007. The figure 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 2021. Confidence level 90%. Percent.

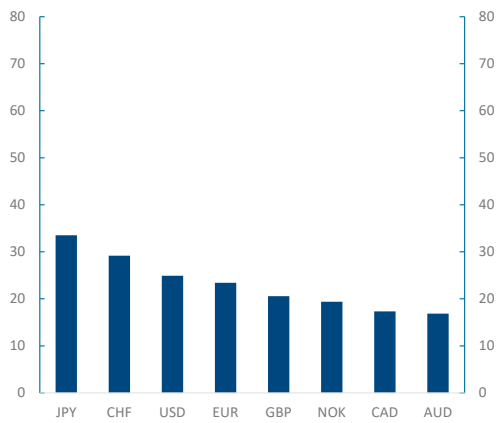


Chart 6 Expected shortfall of actual portfolio as at 31 December 2021. Confidence level 95%. Percent.

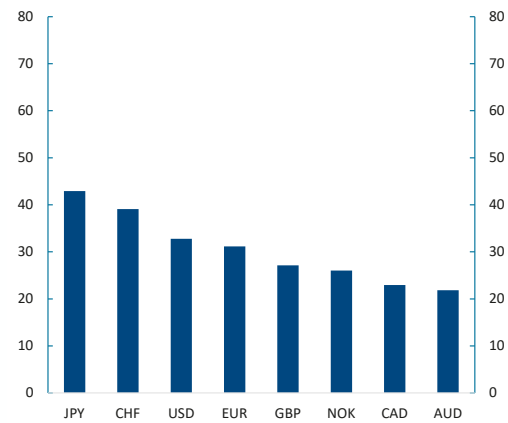


Chart 7 Expected shortfall of actual portfolio as at 31 December 2021. Confidence level 97.5%. Percent.

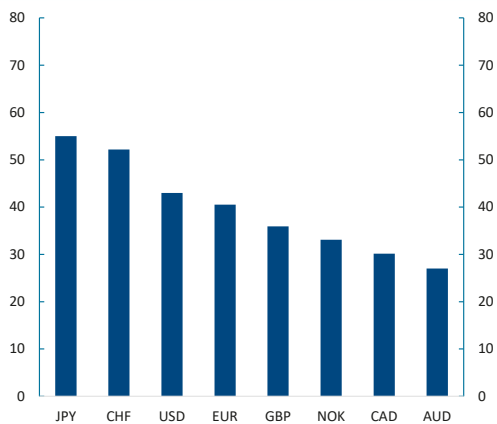
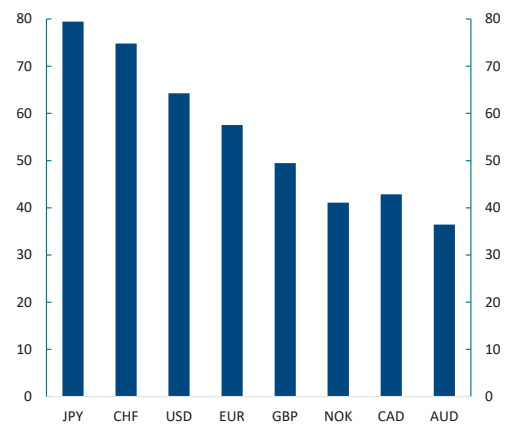


Chart 8 Expected shortfall of actual portfolio as at 31 December 2021. Confidence level 99%. Percent.



Hypothetical stress tests: Systematic risk factors

An important drawback of historical simulations is that future crises may play out differently than in the historical periods covered by the model. In particular, economic and financial conditions change over time, and the current low-yield environment is unique in a historical context. To explore the performance of the fund's portfolio under a range of adverse macroeconomic scenarios, Norges Bank Investment Management performs a forward-looking stress test.

The selection of scenarios is informed by three macro topics that have the potential to shape the macro environment going forward. Inflation and its relationship to growth, as well as the outlook for real rates are the key parameters for our three stress-test scenarios.

Growth slowdown

We assume that long-term growth outlook worsens significantly, i.e., the expected long-term growth moves closer to levels implied by current interest rates. High inflation turns out to be temporary and reverts to below central banks' targets. Central bank policy rates remain at or close to the effective lower bound. Lower inflation combined with the lower bound pushes up real interest rates.

Real rate normalisation

In reaction to high inflation, which is reaching levels not seen for decades in developed markets, central banks tighten monetary policy. Tighter monetary policy leads to a substantial increase in real rates. It also temporarily depresses growth and tightens financial conditions while the long-term growth outlook remains intact.

Stagflation

The combination of extraordinary amounts of monetary and fiscal policy stimulus generates persistently higher inflation without stimulating growth. Central banks are unable/unwilling to reverse monetary stimulus. Under this scenario government bonds lose their hedging properties and thus become riskier. Financial conditions tighten.

To estimate the portfolio impact under the three scenarios outlined above, we translate them into shifts in core return drivers such as dividend growth, risk premia, real rates and inflation expectations. Subsequently, the shifts in core return drivers are translated to broad market segments for each asset class. The GPFG portfolio exposures and shock impact for each market segment are shown in Table 2.

Table 2 Hypothetical scenario impact for GPFG portfolio as at 31 December 2021

	Exposure Billions of kroner Market Value	Shock			Impact		
		Percent			Billions of kroner		
		Growth slow- down	Real rate normali- sation	Stag- flation	Growth slow- down	Real rate normali- sation	Stag- flation
Equities in local currency							
Developed markets - small cap	818	-38	-47	-57	-312	-388	-465
Developed markets - large cap	6,856	-32	-40	-48	-2,204	-2,746	-3,285
Emerging and Frontier markets	839	-24	-30	-36	-202	-252	-301
China A	89	-20	-24	-29	-17	-22	-26
Total in local currency	8,602	-32	-40	-47	-2,736	-3,408	-4,077
Fixed income in local currency							
Developed markets - short term treasuries	794	0	-1	-2	2	-7	-19
Developed markets - long term treasuries	1,162	6	-20	-30	71	-233	-345
Developed markets - government related	364	3	-11	-16	12	-39	-60
Developed markets - corporates	940	4	-15	-24	37	-143	-223
Emerging markets	81	2	-7	-14	2	-6	-12
Total in local currency	3,341	4	-13	-20	124	-428	-657
Real Assets in local currency							
Listed real estate	259	-28	-35	-42	-73	-91	-109
Unlisted real estate	339	-15	-19	-23	-51	-64	-77
Unlisted infrastructure	14	-1	-10	-8	0	-1	-1
Total in local currency	612	-20	-26	-31	-125	-157	-187
Total in local currency	12,340	-22	-32	-40	-2,736	-3,992	-4,921

Note: Small cap and large cap are based on benchmark definitions. Long term treasuries include maturities of 3 years or more. Corporates include securitized bonds and CDX. Unlisted real estate shows gross asset value for exposure and listed real estate only includes equity exposure. The totals include cash.

Table 2 does not include currency movements. Table 3 includes the impact in Norwegian kroner from the baseline model as well as a counterfactual analysis of what the impact would be if the Norwegian kroner appreciated under each scenario.

Table 3 Hypothetical scenarios, impact from currencies for GPFG portfolio as at 31 December 2021

	Exposure Billions of kroner Market Value	Shock			Impact		
		Percent			Billions of kroner		
		Growth slow- down	Real rate normali- sation	Stag- flation	Growth slow- down	Real rate normali- sation	Stag- flation
Portfolio impact in local currency	12,340	-22	-32	-40	-2,736	-3,992	-4,921
Currency impact - developed markets	11,464	6	9	5	689	1,008	618
Currency impact - emerging markets	876	6	11	5	51	98	46
Portfolio impact in NOK	12,340	-16	-23	-34	-1,997	-2,886	-4,257
Counterfactual FX impact							
Portfolio impact in local currency	12,340	-22	-32	-40	-2,736	-3,992	-4,921
Currency impact - developed markets	11,464	-1	-1	-1	-166	-64	-140
Currency impact - emerging markets	876	-2	-1	-2	-21	-8	-18
Portfolio impact in NOK	12,340	-24	-33	-41	-2,924	-4,064	-5,079

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 4 shows relative expected shortfall for the fund as well as each of the fund's investment strategies.

Table 4 Expected shortfall relative to benchmark of investment strategies as at 31 December 2021. 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
Asset management	17
Asset positioning	17
Security selection	35
Internal security selection	32
External security selection	17
Fund allocation	147
Systematic factors	14
Real estate	147
Unlisted real estate	68
Listed real estate	94
Environmental related mandates	18
Allocations	49
Total	152