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 historical simulations for the current asset composition of the fund. The model covers all investments.

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 2019, measured in the currency basket. Returns in percent of entity NAV

Event	First date	Last date	Number of months	Fund	Equity Management	Fixed Income Management
Asian financial crisis	01/07/1997	31/12/1997	6	10.60 %	13.19 %	2.83 %
Russian default	01/08/1998	30/09/1998	2	-8.15 %	-12.49 %	3.25 %
Dot com crash 1	01/09/2000	31/03/2001	7	-5.47 %	-9.33 %	3.35 %
9/11	01/09/2001	30/09/2001	1	-7.60 %	-10.69 %	0.12 %
Dot com crash 2	01/01/2002	30/09/2002	9	-10.98 %	-16.94 %	4.11 %
Global Financial Crisis	01/05/2008	28/02/2009	10	-27.85 %	-36.14 %	0.17 %
Euro debt crisis	01/04/2011	30/11/2011	8	-3.62 %	-7.17 %	4.68 %
Taper Tantrum	01/05/2013	31/08/2013	4	1.26 %	3.85 %	-5.36 %
Oil price decline	01/07/2014	31/12/2014	6	5.74 %	6.69 %	2.45 %
EM slowdown	01/06/2015	30/09/2015	4	-7.02 %	-9.91 %	-1.00 %
Brexit referendum	01/06/2016	30/06/2016	1	-0.51 %	-1.58 %	2.27 %
Volatility spike	01/09/2018	31/12/2018	4	-8.42 %	-11.33 %	-0.08 %

Absolute expected shortfall

Charts 1 to 4 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 1 Expected shortfall of actual portfolio as at 31 December 2019. Confidence level 90%. Percent

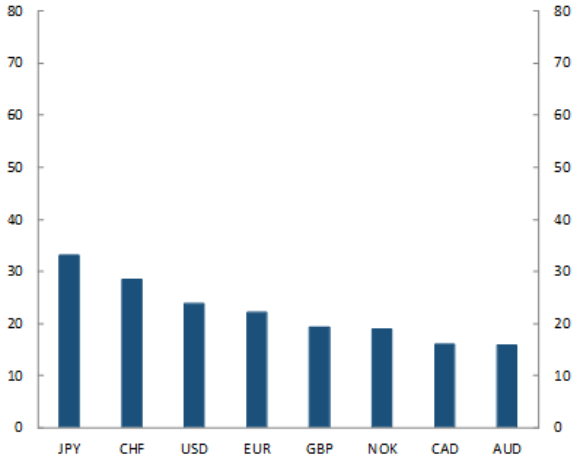


Chart 2 Expected shortfall of actual portfolio as at 31 December 2019. Confidence level 95%. Percent

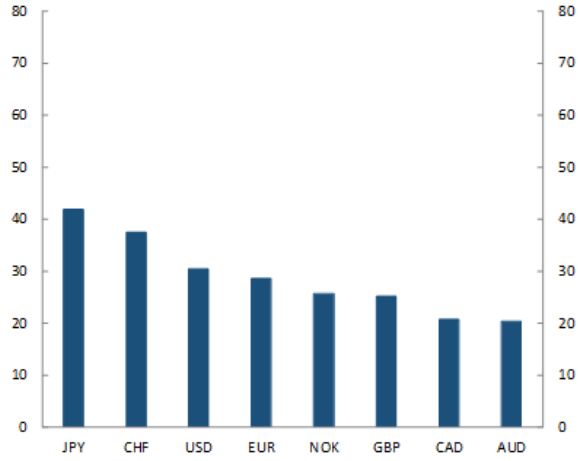


Chart 3 Expected shortfall of actual portfolio as at 31 December 2019. Confidence level 97.5%. Percent

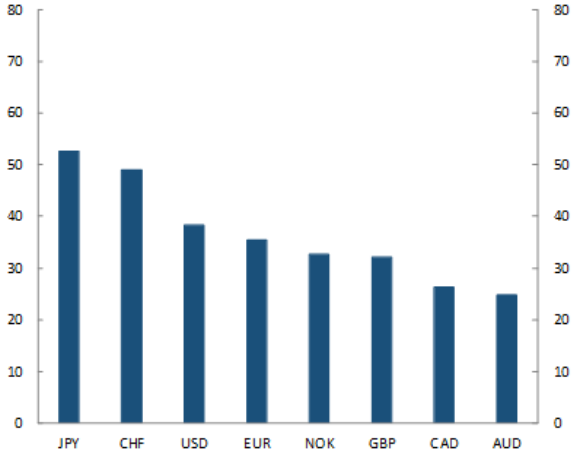
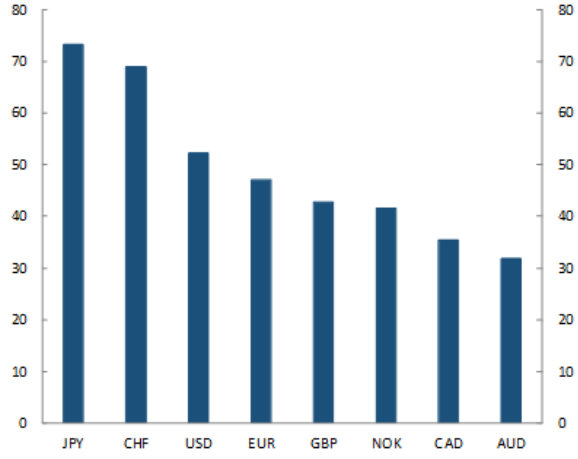


Chart 4 Expected shortfall of actual portfolio as at 31 December 2019. Confidence level 99%. Percent



Hypothetical stress tests: Systematic risk factors

A drawback of historical simulations is that future crises may show different dynamics than stressed periods covered by the model. To investigate portfolio sensitivity to scenarios that are not perfect replications of historical events, Norges Bank Investment Management performs hypothetical stress tests. The three scenarios considered here are recessions associated with increases in uncertainty and decreases in risk appetite. They range from a mild scenario featuring flight-to-quality at one end, an extreme scenario featuring losses on all asset classes at the other end, and a medium scenario in-between. The GPFG portfolio exposures and shock impact for each risk factor is shown in table 2.

Table 2 Hypothetical recession scenario impact for GPFG portfolio as at 31 December 2019

	Exposure		Shock			Impact		
	Billions of kroner Millions of kroner		Prices in percent, Rates in basis points			Billions of kroner		
	Market Value	DV01	Mild	Medium	Extreme	Mild	Medium	Extreme
Equities in local currency								
Developed markets- small cap	802		-15	-35	-55	-120	-281	-441
Developed markets- large cap	5,380		-15	-30	-50	-807	-1,614	-2,690
Emerging and Frontier markets	752		-20	-35	-55	-150	-263	-414
China A	57		-25	-35	-60	-14	-20	-34
Total in local currency	6,991					-1,092	-2,178	-3,579
Fixed income in local currency								
Developed markets- short term treasuries	355	54	-100	-50	100	5	3	-5
Developed markets- long term treasuries	1,110	1,159	-50	-50	100	61	61	-106
Developed markets- government related	308	168	-25	0	200	4	0	-30
Developed markets- corporates	779	448	25	50	500	-11	-22	-157
Emerging markets	239	135	175	200	450	-21	-24	-46
Total in local currency	2,791	1,963				38	17	-344
Real Estate in local currency								
Listed	138		-15	-35	-55	-21	-48	-76
Unlisted	294		-5	-10	-25	-15	-29	-73
Total in local currency	432					-35	-78	-149
Total in local currency	10,088	1,963				-1,090	-2,238	-4,072
Foreign exchange								
Developed markets	9,187		15	0	-15	1,237	0	-829
Emerging markets	901		0	-15	-30	0	-97	-146
Total foreign exchange	10,088					1,237	-97	-975
Total NOK	10,088	1,963				148	-2,335	-5,047

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. Unlisted real estate shows gross asset value for exposure and listed real estate only includes equity exposure. The totals include cash. Equity, real estate and foreign exchange price shocks are in percent. Fixed income interest rate shocks are in basis points.

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 2019. 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
Fund allocation	137
Reference portfolio	31
of which systematic factors	18
Real estate	130
Unlisted real estate	73
Listed real estate	73
Allocations	8
of which environment-related mandates	8
Security selection	30
Internal security selection	25
External security selection	18
Asset management	26
Asset positioning	25
Systematic factors	4
Total	**150**