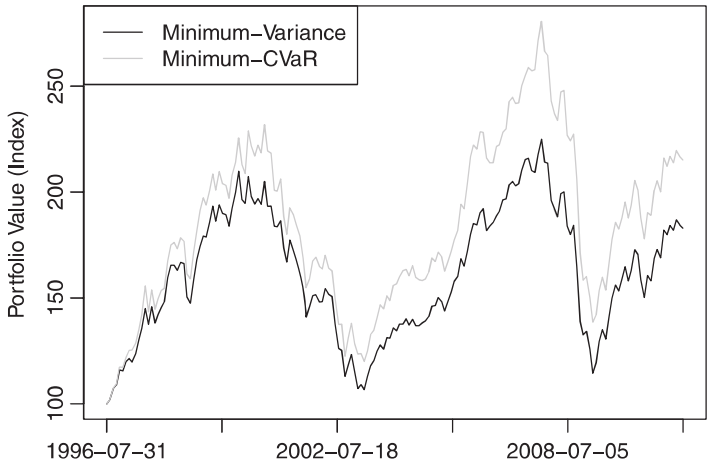

Figure 12.5 Trajectory of mininum-CVaR and minimum-variance portfolio values.

These two equity curves are then displayed by means of lines 17–24 (see Figure 12.5) and the relative performance with respect to the equity line of the GMV portfolio as a barplot in the final lines of the listing (see Figure 12.6).

For this back-test design, the CVaR portfolio approach outperforms the GMV portfolio solutions. However, the sharp portfolio draw-downs witnessed during the financial market crisis during 2007 and 2008 could not be averted by either of the two approaches.

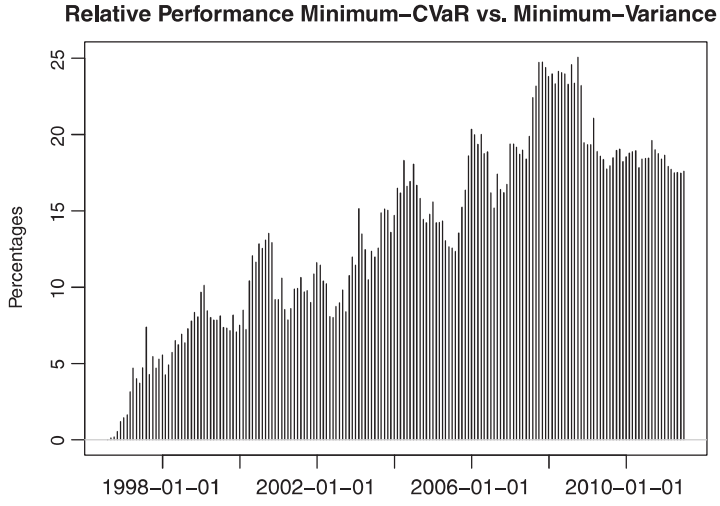

Figure 12.6 Relative performance of minimum-CVaR and minimum-variance portfolios.

12.6.2 Draw-down constrained portfolios

In this example, the solution of a global minimum-variance portfolio is again utilized as a benchmark allocation for long-only investments. The characteristics of this solution are compared with the allocations of portfolios that are restricted by their maximum, average and conditional draw-downs and with a minimum conditional draw-down at risk portfolio. The spectrum of assets covers the major equity and bond markets as well as investment in gold. The R code is presented in Listing 12.3.

First the relevant R packages are brought into memory. Then the `MultiAsset` data set is loaded, which is part of the **FRAPO** package. The data set covers the month's-end prices of a number of equity indexes (S&P 500, Russell 3000, DAX (XETRA), FTSE 100, Nikkei 225 and iShares MSCI Emerging Markets) and fixed income indexes (Dow Jones CBOT Treasury, German REX Performance and United Kingdom gilts (all maturities)) as well as the price of the SPDR Gold Shares exchange traded fund from 30 November 2004 to 30 November 2011. In lines 5–8 the discrete returns are computed and converted to a `timeSeries` object. Commencing in line 11 the solution of the global minimum-variance portfolio is determined and the historic draw-downs are computed with the function `Drawdowns()` contained in the package **PerformanceAnalytics**. Plots of these are displayed through the commands in lines 17–21. The time series plot is created from scratch in order to make its appearance the same as the draw-down plots for the ensuing portfolio plots. The result is provided in Figure 12.7. Incidentally, one could have used the function `chart.Drawdown()` instead, as mentioned in Section 12.5.4.

In the following lines the various draw-down portfolio solutions are computed, with the maximum draw-down of the GMV portfolio serving as anchor value. The conditional draw-down at risk portfolios are computed for a confidence level of 95%.

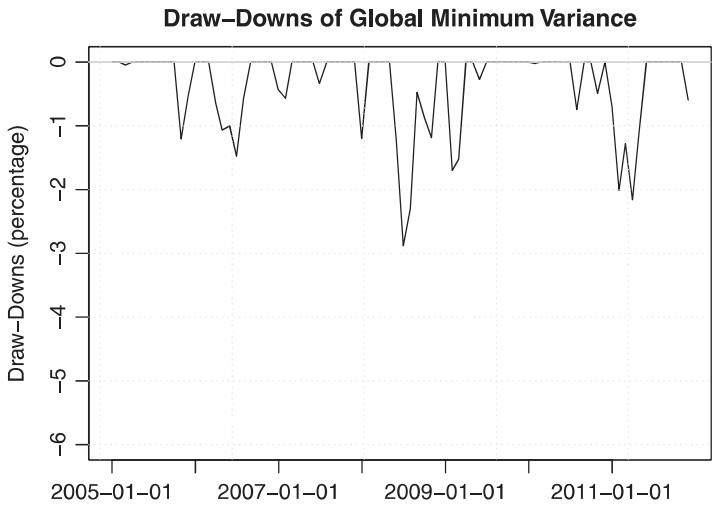

Figure 12.7 Draw-downs of GMV portfolio.

Listing 12.3 Comparison of draw-down and GMV portfolios.

```
library(fPortfolio)
library(FRAPO)
library(PerformanceAnalytics)
data(MultiAsset)
## Return calculation
Rets <- returnseries(MultiAsset, method = "discrete",
                     percentage = FALSE, trim = TRUE)
Rets <- timeSeries(Rets, charvec = rownames(Rets))
## Benchmark portfolio: GMV
gmvspec <- portfolioSpec()
GMV <- minvariancePortfolio(data = Rets, spec = gmvspec,
                            constraints = "LongOnly")
GMVret <- timeSeries(Rets %*% getWeights(GMV),
                     charvec = time(Rets))
GMVDD <- Drawdowns(GMVret)
## Plot of draw-downs for GMV
ylims <- c(-6, 0)
plot(GMVDD * 100, xlab = " ", ylab = "Draw-Downs (percentage)",
     main = "Draw-Downs of Global Minimum Variance", ylim = ylims)
abline(h = 0, col = "grey")
grid()
## Max DD of GMV
GMVMaxDD <- max(-1.0 * GMVDD)
## Draw-down portfolios
MaxDD <- PMaxDD(MultiAsset, MaxDD = GMVMaxDD)
AveDD <- PAveDD(MultiAsset, AveDD = GMVMaxDD)
CDaR95 <- PCDaR(MultiAsset, alpha = 0.95, bound = GMVMaxDD)
CDaRMin95 <- PCDaR(MultiAsset, alpha = 0.95)
## Plot of draw-downs
oldpar <- par(no.readonly = TRUE)
par(mfrow = c(2, 2))
plot(AveDD, main = "(a) AveDD")
plot(MaxDD, ylim = ylims, main = "(b) MaxDD")
plot(CDaR95, ylim = ylims, main = "(c) CDaR")
plot(CDaRMin95, ylim = ylims, main = "(d) Minimum CDaR")
par(oldpar)
```