Scenario Weights for Importance Measurement

An R Package for Sensitivity Analysis

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joint work with Alberto Bettini, Pietro Millossovich and Andreas Tsanakas

https://github.com/spesenti/SWIM

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Efficient Sensitivity Analysis via Scenario Weighting

- ▷ Simulated scenarios from a stochastic model
- ▷ Computationally expensive model runs
- ▷ Monte Carlo sample of input and output

Sensitivity Analysis:

1. Define a **stress** on the output or inputs
2. Derive **scenario weights** (change of measure) such that
   - re-weighted output fulfils the required stress
   - **most plausible / least distorting** (minimal entropy)
   - mathematically consistent

SWIM

An R package.

Stress

```
stress(type = c("VaR", "VaR ES", "mean", "mean
        sd", "moment", "prob", "user"), ...)
```

Stress

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stress(type = c("VaR", "VaR ES", "mean", "mean
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```

```
stress(type = "VaR", x, alpha = c(0.75, 0.9),
        q_ratio = c(1.2, 1.2), k = 1)
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Stress

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stress(type = c("VaR", "VaR ES", "mean", "mean
        sd", "moment", "prob", "user"), ...)
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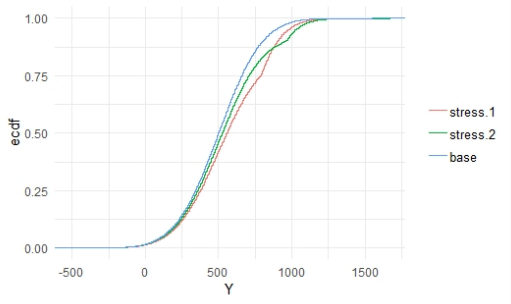
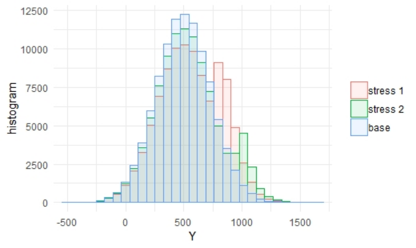
        q_ratio = c(1.2, 1.2), k = 1)
```

```
plot_cdf()
```



Comparison

- summary()
- plot_hist()
- cdf()
- quantile_stressed()

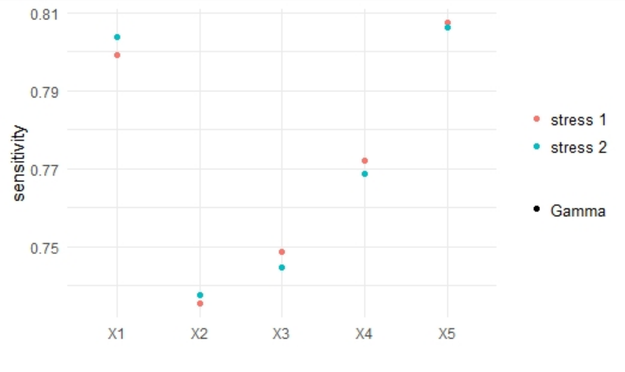


$`stress 1`

	Y	X1	X2	X3	X4	X5
mean	563.41	116.05	108.75	109.98	112.15	116.48
sd	263.89	81.20	46.24	52.49	63.53	81.39
skewness	-0.05	-0.03	-0.01	-0.02	-0.03	-0.03
ex kurtosis	-0.43	-0.22	-0.16	-0.16	-0.17	-0.23
1st Qu.	374.89	59.70	77.01	73.80	68.30	59.76
Median	555.48	116.12	108.81	109.99	112.20	116.35
3rd Qu.	788.79	173.01	140.67	146.25	156.63	174.25

Sensitivity Measures

```
sensitivity()
importance_rank()
plot_sensitivity()
```



Thank you!

https://github.com/spesenti/SWIM

```
install_github("spesenti/SWIM")
```

Appendix

```r
## Consider the portfolio Y = X1 + X2 + X3 + X4 + X5,
## where (X1, X2, X3, X4, X5) are correlated normally
## distributed with equal mean and different standard
## deviations,

set.seed(0)
SD <- round(runif(5, 30, 80))
Corr <- matrix(rep(0.5, 5^2), nrow = 5) +
    diag(rep(1 - 0.5, 5))
xdata <- mvtnorm::rmvnorm(10^5,
    mean =  rep(100, 5),
    sigma = (SD %*% t(SD)) * Corr)
x <- data.frame(rowSums(xdata), xdata)
names(x) <- c("Y", "X1", "X2", "X3", "X4", "X5")
```

```
res <- stress(type = "VaR", x, alpha = c(0.75, 0.9),
   q_ratio = c(1.2, 1.2), k = 1)

summary(res, wCol = 1)
plot_cdf(object = res, xCol = , base = TRUE)
plot_hist(object = res, xCol = , base = TRUE)

sensitivity(res)
importance_rank(res, xCol = 2:6)
plot_sensitivity(res, xCol = 2:6, type = "Gamma")
```

References

Csiszár, I. (1975).
I-divergence geometry of probability distributions and minimization problems.
The Annals of Probability, 3(1), 146–158.

Pesenti, S. M., Millossovich, P., & Tsanakas, A. (2019).
Reverse sensitivity testing: What does it take to break the model?
European Journal of Operational Research, 274(2), 654–670.