Is the Dutch stock market getting riskier?

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Working Paper

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In this paper, we compared the distribution of the AEX Index monthly returns of the period 1994-2005 against the period 2006-2017 to evaluate the presence of negative extreme events. Through the analysis of the Return Level value (R_{10}) we have concluded that AEX Index period 1994-2005 has a similar risk that the period 2006-2017.

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I. AEX Index Distribution

We estimated monthly returns of AEX 500 Index from 1994 to 2017, downloaded from Yahoo Finance, for a total 288 observations.

Figure I depict AEX Index monthly returns, measured as the log return of the last day of the month to the last day of the next month.

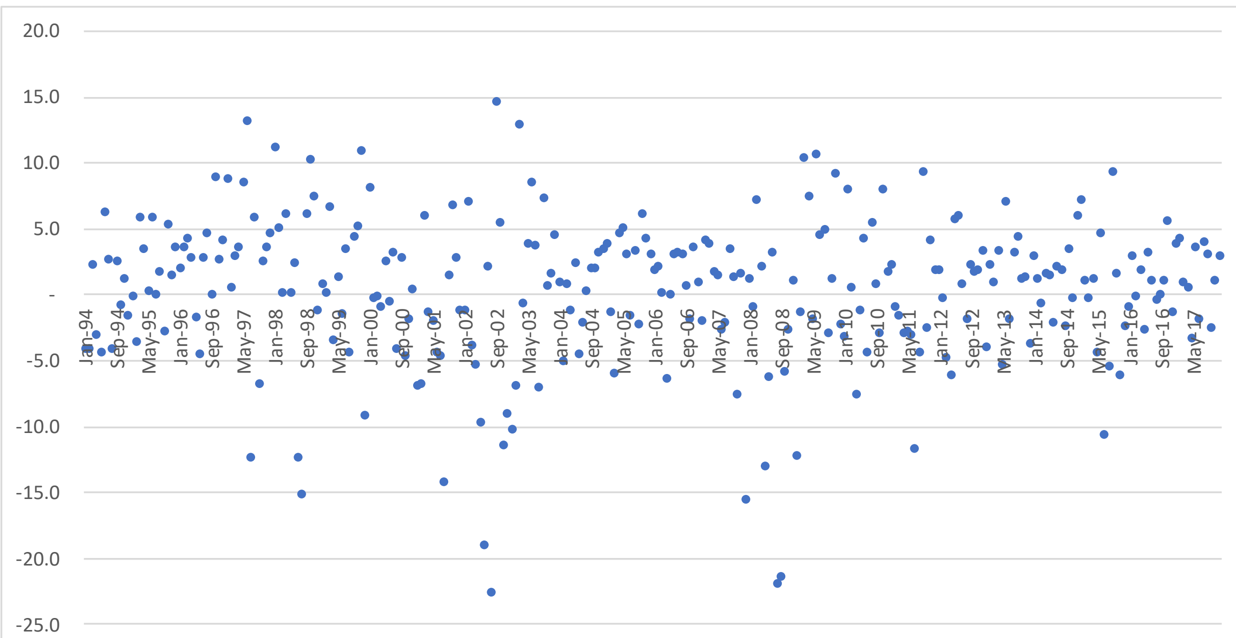


Fig. I. AEX Index monthly returns 1994-2017

We split, ad-hoc, the sample in two periods, 1994-2005 and 2016-2017.

Next table summarized main statistical data:

Period	Obs.	Mean	Std. Dev.
1994-2005	144	0.57%	0.0597
2006-2017	144	0.15%	0.0517

II. Extreme Events

Extreme events occur when a risk takes values from the tail of its distribution (McNeil, 1999).

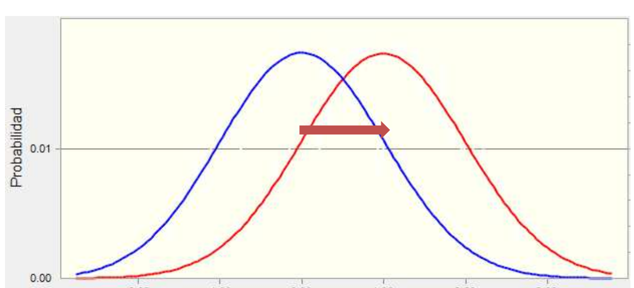
For a deeper mathematical treatment of the extreme value theory, Coles (2001) is recommended.

II.1. Extreme Events over Time

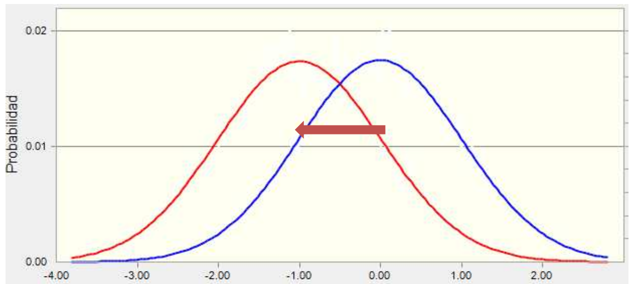
Change in the mean and the variance of the distribution over time will generate change in extreme events occurrence.

Next graphs show the change in negatives and positive value of returns using a comparison against the normalized distribution ($\mu = 0.0$ and $\sigma = 1.0$) as base case:

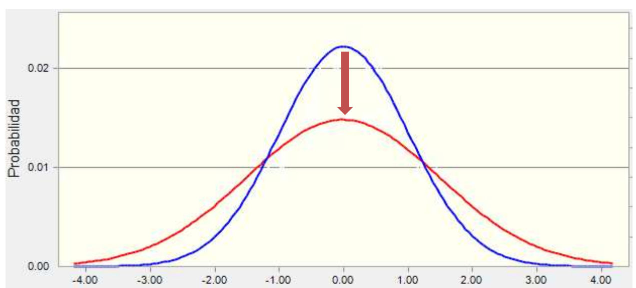
a) An increase in mean and no change in variance ($\mu = 1.0$ and $\sigma = 1.0$), produce less negative returns, and more positive returns along with more record positive returns.



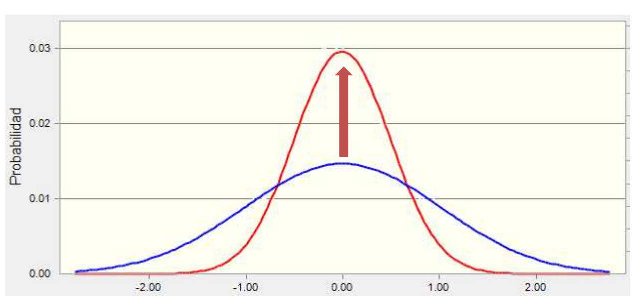
b) A decrease in mean and no change in variance (μ = -1.0 and σ = 1.0), generate more negative returns besides more record negative returns, and less positive returns.



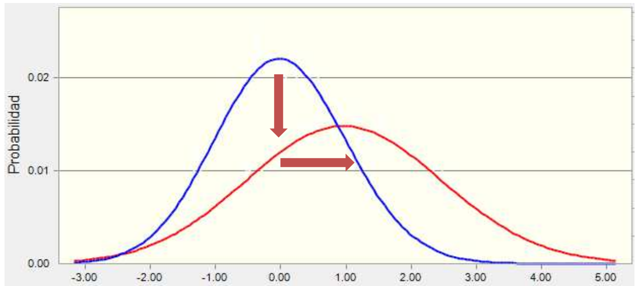
c) Increase in variance and no change in mean (μ = 0.0 and σ = 1.5) make more negative returns and more record negative returns, in addition to, more positive returns and more record positive returns.



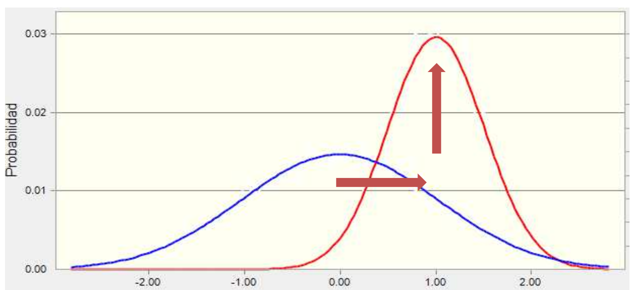
d) Decrease in variance and no change in mean (μ = 0.0 and σ = 0.5) cause less negative returns and less record negative returns, as well as, less positive returns and less record positive returns.



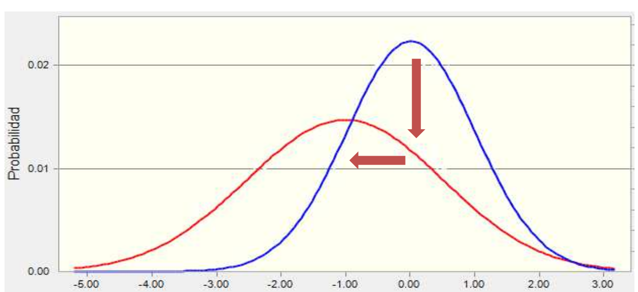
e) An increase in mean and an increase in variance (μ = 1.0 and σ = 1.5), produce more positive returns and more record positive returns.



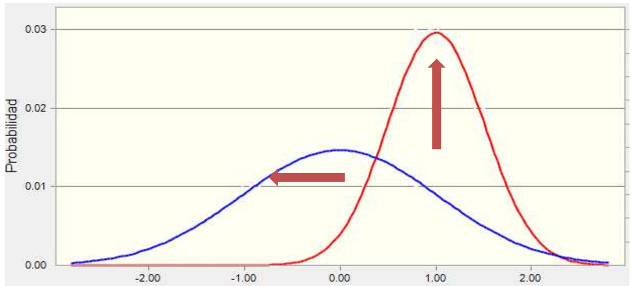
f) An increase in mean and a decrease in variance (μ = 1.0 and σ = 0.5), generate less negative returns and less record negative returns.



g) A decrease in mean and an increase in variance (μ = -1.0 and σ = 1.5), cause more negative returns and more record negative returns.



h) A decrease in mean and a decrease in variance (μ = -1.0 and σ = 0.5), create less negative returns and less record negative returns.



II.2. Return Level

The return level R_k^n is the level expected, on average, to be exceeded in one out of *k* periods of length *n*.

The return period is the amount of time expected to wait for particular return level to be exceed; return period is the inverse of the probability of an event, a called "100 years event" has a 1% (1/100) probability of exceed the record level in any one year.

For a Generalized Pareto Distribution, the *k* year return level is defined:

$$R_k \approx \quad \mu + \frac{\tilde{\sigma}}{\tilde{\xi}}\left([k * n_y * \Pr(X>\mu)]^{\xi} - 1\right) \text{ for } \tilde{\xi} \neq 0$$

where μ is the defined threshold, $\tilde{\sigma}$, and $\tilde{\xi}$ are the parameters of the Generalized Pareto Distribution, n_y is the number of observations per year, and Pr (X>μ) is equal to number of exceedances of threshold (*Nu*) divided by total number of observations (*N*).

Using the in2extRemes Toolkit developed by Eric Gilleland and Richard Katz, within statistical software R, we conducted the estimation of the Generalized Pareto Distributions.

II.2.1. Left Tail

According to Figure II and Figure III threshold of 3% monthly lose, is a "good" selection. Indeed, the mean residual life plot is "nearly linear" around that value; and the reparametrized scale and shape estimates seem to be constant on a range around that value.

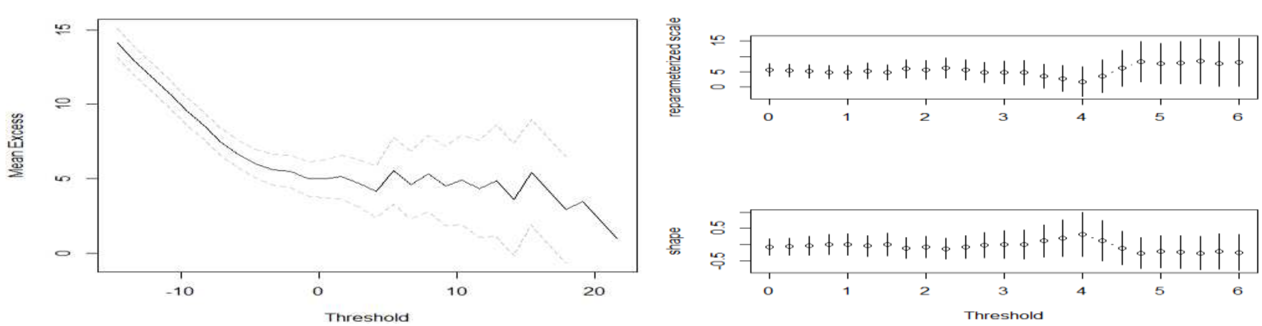


Fig. II. Mean Residual Life and Shape estimates plots, AEX Index monthly returns, 1994-2005.

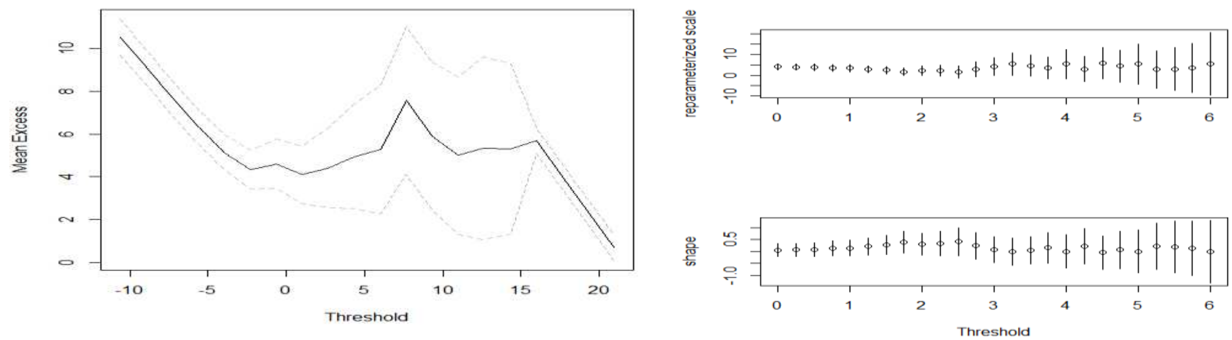


Fig. III. Mean Residual Life and Shape estimates plots, AEX Index monthly returns, 2006-2017.

The selection of 3% negative return as threshold, generated 34 exceedances of threshold for the period 1994-2005 and 25 exceedances of threshold for the period 2006-2017.

For the period 1994 – 2005, the AEX Index recorded a total of 56 cases of negatives monthly returns, and a maximum negative monthly return of 22.6%.

For the period 2006 – 2017, the AEX Index recorded a total of 59 cases of negatives monthly returns, and a maximum negative monthly return of 21.9%.

AEX Index monthly returns for that period 1994 – 2005 give a Generalized Pareto Distribution with parameters (μ): 3.0, (σ): 4.7150240 and (ξ): 0.0000001

AEX Index monthly returns for that period 2006 – 2017 give a Generalized Pareto Distribution with parameters (μ): 3.0, (σ):4.5019323 and (ξ): 0.0917845

Defining an extreme event as a 10% probability of exceed the record level in any one year, such return level R_{10} is 18.767% % with 95% confidence interval of (11.53%, 25.99%) for the period 1994-2005, and 18.765% with 95% confidence interval of (10.02%, 27.50%) for the period 2006-2017.

Next table summarized main AEX Index negative monthly returns events by period:

Period	Max. Loss	# Loss>-3%	# Loss>-10%	# Loss>-18%
1994-2005	-22.62%	34	8	2
2005-2017	-21.96%	25	7	2

III. CONCLUSION

Through the analysis of the Return Level value (R_{10}) we have concluded that AEX Index period 1994-2005 has a similar risk that the period 2006-2017.

Future lines of research could apply estimation of return level using extreme value theory to others time periods, stocks, portfolio analysis, or markets like commodities and currencies.

REFERENCES

McNeil, A. J. (1999). Extreme Value Theory for Risk Managers. *Internal Modelling and CAD II*. RISK Books, 93-113.

Coles, S. (2001). *An Introduction to Statistical Modeling of Extreme Values*. Springer, London.