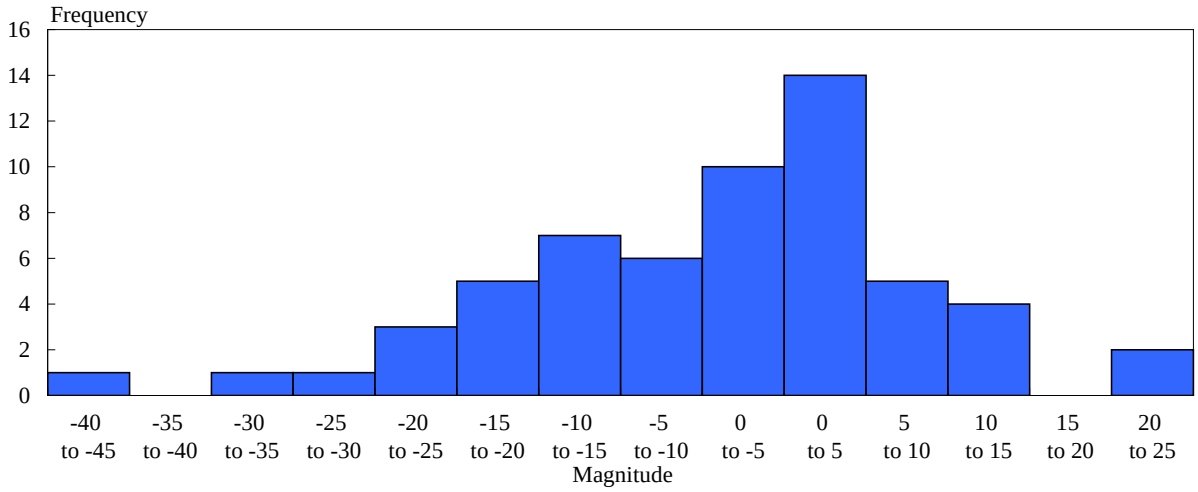
Box 2.2

Statistical analysis for the tail risks of merchandise exports

Hong Kong is a small open economy, and its trade sector has long been rather susceptible to shocks from the external front. This is particularly so for Hong Kong's merchandise trade. As the performance of merchadise exports is crucial to Hong Kong's overall economic growth, it is useful to review the past volatility of such exports, by means of a statistical investigation, to get the feel of their likelihood of experiencing an exceptionally large decline in any particular year. The probability distribution so obtained, though necessarily crude, could be of reference value for building the worst case scenario in stress tests that required input assumptions on export performance.

The present exercise makes use of a pure statistical theory, commonly used in gauging tail risks, to shed some light on the issue without analysing the underlying economic causes for the fluctuations in exports. Monthly figures of Hong Kong's merchandise exports, in terms of the year-on-year rate of volume change, from January 1953 to December 2011 are used(1). By extracting the smallest value from each year, a sample of annual minima is obtained. The data are plotted as a histogram in ***Chart 1***. The histogram shows that most of these minima clustered between +5% and -15%, with some outliers lying beyond the thresholds of +20% and -40%. The histogram roughly resembles the bell-shaped normal distribution. Further inspection through the quantile-quantile plot and the mean excess plot(2) (***Chart 2***) suggests that the distribution of the sample does not differ noticeably from the normal distribution and the evidence for existence of fat tails is not strong(3). Other statistical tests(4) also fail to reject the assumption of normal distribution.

Chart 1 : Histogram of annual minima of Hong Kong's merchandise exports year-on-year rate of change after netting out price changes



(1) For the period before 1983, prior to the compilation of the quantum index of merchandise trade, price changes in merchandise exports were crudely estimated by domestic inflation. The merchandise exports values were also adjusted for exchange rate fluctuations, and the months of January and February were jointly considered to smooth out any potential distortions due to the timing of the Lunar New Year.

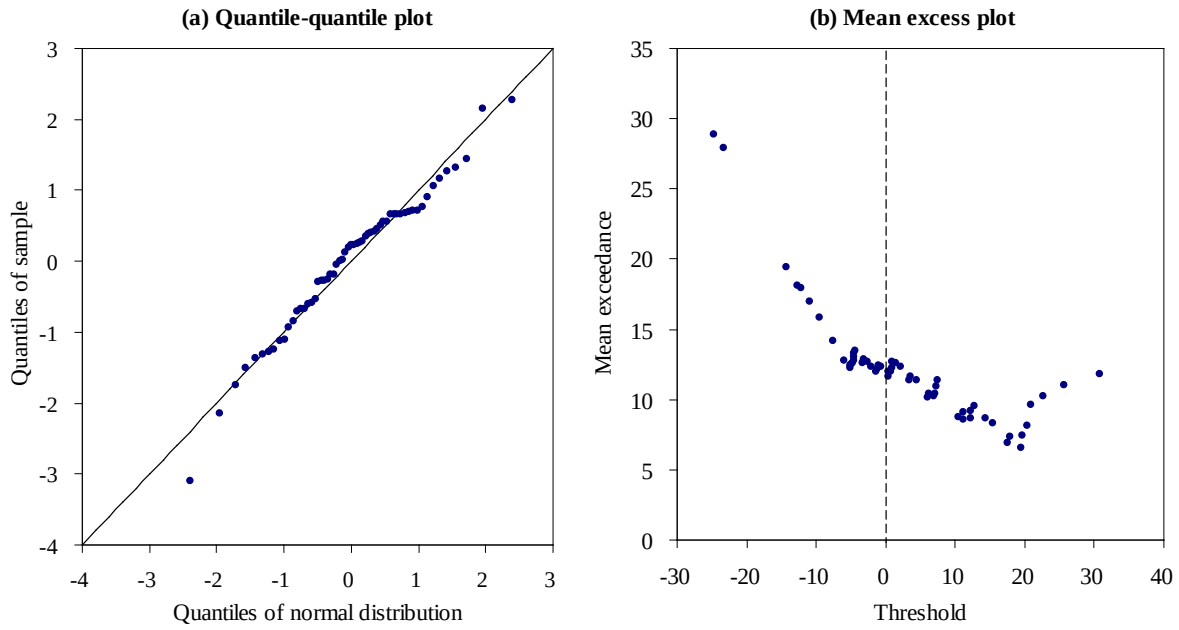
(2) Quantile-quantile plot matches the quantiles of two probability distributions against each other. If the two distributions being compared are similar, the points on the quantile-quantile plot will approximately lie on the 45° line. Mean excess plot maps the threshold values to the average exceedance above the threshold. For distributions with fat tails, the larger the threshold the larger the mean excess will be and the diagram should show aligned points with a positive gradient. With a focus on the downside risk, for this chart the signs of the sample data were reversed so the relevant part is to the right of the dashed line.

(3) Should the distribution be identified with fat tail, the extreme value theory provides a better theoretical foundation for statistical analysis. In fact, attempts have been made to employ the extreme value theory in conducting the study but the results are qualitatively the same.

(4) Including Anderson-Darling test and Jarque-Bera test.

Box 2.2 (Cont'd)

Chart 2 : Visual inspection for normality



Building on the assumption of normal distribution, a summary of statistical analysis is depicted in ***Table 1***. The first column shows the inferences based on full sample estimation, while the other two columns use a smaller sample to allow for cross-checking of results. The first two rows are self-explanatory. The next three rows of the table give the probabilities of certain sizes of year-on-year decline happening in the worst performing month of a year. The last four rows present the order of magnitudes of the exceptional plunge expected from occurrences in the designated frequencies(5).

Table 1 : Summary of analysis on merchandise exports

	Full sample (1953 - 2011)	Sub-sample (1953 - 2001)	Sub-sample (1953 - 1991)
Sample mean (%)	-3.8	-4.1	-5.1
Sample standard deviation (%)	12.5	12.9	13.7
Probability of occurrence in the worst performing month of any particular year :			
Decline of 10% or more	31.0%	32.5%	35.9%
Decline of 20% or more	9.8%	11.0%	13.8%
Decline of 30% or more	1.8%	2.3%	3.5%
Potential size of exceptional decline (%) :			
Once-in-five-years decline	-14.3	-15.0	-16.6
Once-in-ten-years decline	-19.9	-20.7	-22.7
Once-in-20-years decline	-24.4	-25.4	-27.6
Once-in-50-years decline	-29.5	-30.7	-33.2

(5) This is the rate of decline (R^k) expected to be exceeded once out of k years and is given by the formula :

$$R^k = \Phi^{-1}\left(1-\frac{1}{k}\right)$$

where Φ^{-1} is the inverse cumulative normal distribution function.

Box 2.2 (Cont'd)

The first column suggests that there is almost one-in-three chance that Hong Kong's merchandise exports would drop by more than 10% year-on-year in the worst performing month in any particular year. Yet the probability of seeing a 20% decline shrinks sharply to about one-tenth and even much less for a decline of more than 30%. The corresponding probabilities obtained from the smaller sub-samples covering the earlier years are slightly larger, reflecting the more volatile external trade back then.

On the other hand, the full sample analysis shows that the magnitude of a once-in-five-years decline is roughly about 15% year-on-year, varying slightly across different sample periods. The interpretation is that merchandise exports are expected to fall by at least about 15% year-on-year in the worst performing month in any five-year period. Observation on the sample data over the past several decades seems to be largely consistent with this result. Calculations also show that the significant plunge in merchandise exports in 2009 (falling by almost 23% year-on-year in the first two months of 2009) is pretty much a once-in-20-years decline. Extending this analysis further, the results from the full sample analysis imply that a once-in-50-years decline would be about 30%, which had happened twice in our sample (in 1953 and 1954) during the truly exceptional period of the embargo imposed by the United Nations due to the Korean War. Analyses using the smaller sub-samples also point to the same order of magnitude.

The statistical analysis above provides a simple summary on the tail risks in Hong Kong's merchandise exports. Like any other statistical analyses of this sort, the dynamic relationships between Hong Kong's merchandise exports and the underlying macroeconomic factors are not considered here. Therefore, the results should be interpreted with caution. Moreover, this analysis only focuses on the worst performing month in any particular year, while giving no accounts on the performance in the second-worse as well as the other months. As such, the largest decline could be the trough of a prolonged period of depression or might just be a sudden plunge amid a period of solid growth. Nevertheless, the findings may serve as useful reference, from the statistical perspective, for benchmarking the relevant assumptions used in stress tests for risk management purposes.