P2.T7.804.1

(Please note: This question is obviously inspired by practice question #1 in GARP's 2017 Part 2 Practice Exam.) Freshzim Investment Bankers has an active position in commodity futures and is using the peaks-over-threshold (POT) approach according to extreme value theory (EVT) for estimating value at risk (VaR) and expected shortfall (ES). The firm's risk managers decided to set a threshold level of 6.00% to evaluate excess losses. This choice of the threshold is consistent with their finding that 3.0% of the observations are in excess of this threshold value. As displayed below, aside from the threshold choice (i.e., u = 6.00 as Dowd's threshold is denominated in % terms and perhaps unexpectedly enters the EVT POT VaR and ES as 6.00), empirical analysis suggests the two other distributional parameters: scale, $\beta = 0.80$; and shape (aka, tail index), $\xi = 0.23$

Parameter	
Loss threshold, u	6.00%
No. (#) of observations, N	900
No. (#) of obs. that exceed threshold, N(u)	27
N(u)/N	3.00%
Scale, β	0.80
Shape; aka, tail, ξ	0.23

At the 99.0% confidence level, the position's VaR under the POT approach is 7.00%. Which is **nearest** to the corresponding 99.0% expected shortfall (ES)?

A. 8.34%

B. 9.99%

C. 10.50%

D. 12.47%

A is CORRECT.

ES = (VaR + β - ξ*u)/(1-ξ) = (7 + 0.80 - 0.23 * 6)/(1 - 0.23) = 8.33766

Discuss here in the forum: https://forum.bionicturtle.com/threads/p2-t7-804-extreme-value-theory-evt-approaches-dowd-ch-7.13994/

P2.T7.804.2

Sandra is trying to fit a distribution to the extreme loss tail of a historical financial return dataset. She has a good fit for the parent (aka, body and shoulders) distribution, but she has not settled on her extreme value theory (EVT) approach. Her situations include the following five issues:

I. The distribution F(x) is actually unknown; i.e., it could be anything
II. The loss data somewhat cluster; that is, losses are not strictly i.i.d.
III. The parent (i.e., non extreme loss) distribution is well-characterized by a student's t distribution; that is, the parent is non-normal
IV. The end users might prefer the extreme loss tail distribution be characterized by a Gumbel so that F(x) has exponential tails
V. The end users do prefer that the extreme loss tail distribution itself exhibit right-skew; aka, positive skew

Her end users have expressed a preference for the generalized extreme-value distribution, frankly because they are more comfortable with the traditional block maxima approach. Which of these issues, in theory, effectively **DISQUALIFIES** the generalized extreme-value (GEV) distribution as a candidate for application?

A. Only I., because F(x) does need to be specified of course

B. Both I. and II., because F(x) needs to specified and the loss data must be i.i.d.

C. Both IV. and V., because GEV can be heavy-tailed but will have zero skew, and further should be the Weibull case

D. None of these issues disqualify the GEV distribution

D is CORRECT.

Please note:

Please note:

- Analogous to CLT (which itself does not need an assumption for the underlying distribution), EVT does not require that F(x) is known.
- Importantly, EVT does assume i.i.d. however, Dowd explains that block maxima GEV is a good choice to overcome clustering.
- There is no formal requirement of the parent distribution.
- Depending on the tail index, GEV can be either Frechet ($\xi > 0$), which is useful because it is heavy tailed, the Gumbel ($\xi = 0$), or the Weibull ($\xi < 0$), which is less useful because it exhibits light tails. All tend to be (or at least can be) right-skewed.

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P2.T7.804.3

To retrieve the value at risk (VaR) under the generalized extreme-value (GEV) distribution, Dowd shows the derivation that results in the following equation which can characterize a heavy-tailed Frechet distribution:

$$VaR =_{n} -\frac{n}{n}[1 \; - \; (-n \; ln \; (a))^{-n}]$$

Let's assume the following somewhat "realistic" parameters:

- location, μ = 3.0%,
- scale, σ = 0.70%,
- tail index, ξ = 0.60%, and

If the sample size, n = 60, then which is **nearest** to the implied 99.90% VaR?

A. 6.50%

B. 8.14%

C. 11.90%

D. 15.75%

B is CORRECT.

Per Dowd's formula 7.5a: 3.0 - 0.70/0.60*(1-(-60*LN(0.9990))^-0.60) = 8.14.

Discuss here in the forum: https://forum.bionicturtle.com/threads/p2-t7-804-extreme-value-theory-evt-approaches-dowd-ch-7.13994/

P2.T7.805.1

Robert the Risk Analyst is employing the peaks-over-threshold (POT) methodology for estimating value at risk (VaR) and expected shortfall (ES) for his firm's active positions. His initial model makes the following assumptions:

Parameter of peaks-over-threshold (POT) EVT model	
Loss threshold, u	5.00%
No. (#) of observations, N	1,350
No. (#) of obs. that exceed threshold, N(u)	64
N(u)/N	4.74%
Scale, β	0.70
Shape; aka, tail, ξ	0.20

He wants to experiment with tweaks to his model. First, he increases the threshold from u = 5.0% to 6.0%; consequently, he observes the 99.0% expected shortfall (ES) increase from 7.47% to 8.47%. After reverting the threshold back to 5.0%, he experiments with a series of additional changes to the model, but only one at a time so that each change is ceteris paribus.

Each of the following changes, ceteris paribus, will increase the 99.0% expected shortfall (ES) **EXCEPT** which of the following changes will decrease the ES?

A. Increase the confidence from 99.0% ES to 99.9% ES

B. Increase the scale parameter only (ceteris paribus) from β = 0.70 to β = 0.85

C. Double the tail index (aka, shape) only (ceteris paribus) from ξ = 0.20 to ξ = 0.40

D. Increase the number of observations from N = 1,350 to N = 1,500, but without any additional N(u), such that N(u)/N is reduced

D is CORRECT

D is CORRECT.

A reduction of N(u)/N implies a lower percentage of losses in excess of the threshold; consequently, the ES is reduced. In this case, if N = 1,500, then N(u)/N reduces to 4.27% and the 99.0% ES reduces to ~ 7.35% (from 7.47%).

In regard to (A), (B), and (C), each implies an increase in the 99.0% ES. Specifically,

- An increase to 99.9% confidence implies an increase (from the baseline of 7.47%) in the ES to ~ 10.97%
- An increase in the scale parameter to $\beta = 0.85$ implies an increase in the ES to ~ 8.00%
- A doubling of the tail index to $\xi = 0.40$ implies an increase to in the ES to ~ 8.69%

Discuss here in the forum: https://forum.bionicturtle.com/threads/p2-t7-805-extreme-value-theory-evt-gev-versus-pot-dowd-ch-7.14016/

P2.T7.805.3

Sally the Risk Analyst is comparing the generalized extreme value (GEV) method to the peaks-over-threshold (POT) method as she aspires to characterize the distribution of extreme losses in her firm's loss database. Her assumptions and/or preference include the following:

I. The losses are probably independent and identically distributed (i.i.d.)
II. However, it is possible there is some "time dependency" in the loss data
III. She does not actually know the character of the parent's distribution, F(x)
IV. She prefers to avoid calibrating either the scale (β or σ) or tail index (ξ) parameters
V. She may need to assume multivariate extremes

In terms of a direct comparison (and contrast) between GEV versus POT, which of the above factors by itself suggests that she should choose POT over GEV; i.e., by itself favors POT over GEV?

A. None

B. II. only (time dependency suggests POT is better than GEV)

C. IV. only (POT avoids shape and tail, requiring only threshold selection)

D. All of them

A is CORRECT.

Specifically:

- Both approaches assume i.i.d. losses,
- But if there is time-dependency (i.e., non-iid), then GEV offers an overcoming approach; i.e., if the loss data cluster, then GEV is favored over POT.
- Neither approach needs to know the parent distribution, F(x).

- Both approaches require calibrating scale and tail; GEV additionally requires location, μ, while POT requires a threshold, u.
- Multivariate EVT does not per se favor POT over GEV.

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P2.T7.805.2

Barbara the Risk Manager is trying to select a threshold in her peaks-over-threshold (POT) extreme value theory (EVT) model. Because she is a certified Financial Risk Manager (FRM) she realizes that her choice of the threshold, in Dowd's words, "is the weak spot of POT theory: it is inevitably arbitrary and therefore judgmental."[1] Her data set contains 1,000 observations. At its current calibration, the threshold implies 50 losses such that N(u)/N = 50/1,000 = 5.0%. In regard to adjusting the threshold, which of the following statements is **TRUE**?

A. If she increases the threshold, the bias increases

B. If she increases the threshold, the variance decreases

C. She should employ the maximum likelihood estimation (MLE) method in order to determine the objectively optimal threshold

D. If she increases the threshold for the same dataset, she should expect N(u)/N to decrease but with unclear effect on VaR and ES (they may increase or decrease)

D is CORRECT.

An increase in the threshold, u, given constant observations implies a reduction in the number of exceptions, N(u), and therefore a reduction in N(u)/N. The effect is unclear because the threshold increase will increase the VaR/ES, but the decrease in N(u)/N will decrease VaR/ES.

In regard to (A), (B) and (C), each is FALSE.

- **In regard to false (A) and (B):** An increase the threshold reduces bias: the POT GP is a limiting (aka, asymptotic) distribution analogous to how the normal is limiting distribution for the sample mean under CLT, but the GPD is the limiting distribution for the extreme tail under EVT; a higher threshold exploits this convergence with less bias. However, a higher threshold also "captures" fewer extreme losses for the dataset, and the resultant smaller sample implies a higher variance (for the parameter estimates).
- **In regard to false (C),** this contradicts Dowd's warning (in the assumption) the threshold selection in unavoidably subjective.

[1] Kevin Dowd, Measuring Market Risk, 2nd Edition (West Sussex, England: John Wiley & Sons, 2005)

Discuss here in the forum: https://forum.bionicturtle.com/threads/p2-t7-805-extreme-value-theory-evt-gev-versus-pot-dowd-ch-7.14016/

P2.T7.608.1

In January 2016, the Basel Committee on Banking Supervision (BCBS) issued its Revised Framework for Market Risk Capital Requirements which is also called the Fundamental Review of the Trading Book (FRTB). Compared to Basel I and Basel II.5, each of the following is true about the FRTB **EXCEPT,** which is false?

A. The internal models approach (IMA) under Basel II.5 required the sum of two components, current VaR plus stressed VaR, but the FRTB requires only a single stressed expected shortfall (ES)

B. IMA under Basel I and II.5 calculated market risk capital using a 10-day time horizon, but the FRTB uses five different horizons (10, 20, 60, 120 and 250 days) depending on the liquidity of the market variable

C. IMA under Basel II.5 required the Default Risk Charge (DRC), but the FRTB eliminates this component which implies that the median (and weighted average) total market risk capital requirement is likely to be reduced due to the change from Basel II.5 to the FRTB

D. IMA under Basel I and Basel II.2 calculated the market risk capital requirement based on value at risk (VaR) with a 99.0% confidence level, but the FRTB calculates the market risk capital requirement based on expected shortfall (ES) with a 97.5% confidence level

C is CORRECT.

Basel 2.5 had the Incremental Risk Charge (IRC), which the FRTB effectively replaces with the Default Risk Charge (DRC); further, the FRTB implies a significant increase in market risk capital requirements.

Specifically, in the Explanatory Note on the Revised Minimum Capital Requirements for Market Risk, the Committee writes (**emphasis ours**), "4. Impact analysis: "... On the whole, based on data provided by banks as of end-June 2015, the revised framework produces market risk risk-weighted assets (RWAs) that account for less than 10% of total RWAs, compared to approximately 6% under the current framework. Compared to the current framework, **the revised market risk capital standard is likely to result in an approximate median (weighted average) increase of 22% (40%) in total market risk capital requirements** (i.e. including securitisation and non-securitisation exposures within the scope of the market risk framework)."[1]

In regard to (A), (B), and (D), each is TRUE.

In summary, with respect to the internal models approach (IMA):

- In Basel I, market risk capital is calculated from the current 99% ten-day VaR, which is assumed to be sqrt(10) times the current 99% one-day VaR.
- In Basel II.5, there are two components of the capital, and each component is assumed to be sqrt(10) times the corresponding one-day VaR: One component is calculated from the current 99% VaR (same as Basel I); plus the other component which is calculated from the stressed 99% 10-day VaR.
- In the FRTB, capital is calculated from the 97.5% stressed ES, with the time horizon for a variable being dependent on its liquidity (but only the single stressed ES). The FRTB uses five different horizons (10, 20, 40, 60, and 120 days) depending on the liquidity of the market variable; e.g., Interest rate (EUR, USD, GBP, AUD, JPY, SEK, and CAD) and large-cap equity variables use a 10-day horizon; small-cap equities and energy prices use a 20-day horizon.
- The incremental risk charge (IRC) in Basel 2.5 is replaced by the default risk charge (DRC) in the FRTB.

[1] Explanatory Note on the Revised Minimum Capital Requirements for Market Risk (January 2016, see http://www.bis.org/bcbs/publ/d352.htm

Discuss here in the forum: https://forum.bionicturtle.com/threads/p2-t7-608-fundamental-review-of-the-trading-book-hull.9768/

P2.T7.608.3

If the distribution is normal, Kevin Dowd[1] (in Managing Market Risk, 2nd Edition) explains that expected shortfall (ES) has an elegant calculation as given by the following:

$$ES = -_{P/L} +_{P/L} \frac{(z)}{1-}$$

For example, if the daily mean, μ, is +1.0% and the daily standard deviation, σ, is 5.0%, then the 99.0% ES = -1.0% + 5.0%*[NORM.S.DIST(2.326, FALSE)/0.010] ~= 12.326%, where NORM.S.DIST(2.326, FALSE) is the standard normal probability density function (pdf) at the quantile, z(99.0%), equal to 2.326.

However, Hull provides the alternative method (see below), which does not require a standard normal lookup. In this function, X is the confidence level, and Y is the standard normal quantile; aka, inverse CDF or, as Hull writes, “Y is the point on a standard normal distribution that has probability of (1-X) of being exceeded.”[2] For example, if X is 99.0%, then Y is 2.326.

$$+\exp(-Y^2/2)/\left[\sqrt{2}(1-X)\right]$$

Using Hull’s expression and assuming returns are normally distributed where the daily mean return is +1.0%, and the daily standard deviation is 5.0%, which of the following is **nearest** to the daily 97.5% expected shortfall (ES)?

A. 4.00%

B. 7.22%

C. 8.80%

D. 10.69%

D is CORRECT.

10.686% = -1.0% + 5.0%*exp(-1.960^2/2)/[sqrt(2*3.142)*0.025] = -1.0% + 5.0%*2.338

However, no calculation to determine the quantile is necessary if we recall that normal 97.5% ES corresponds to 99.0% VaR Hull, which is approximately 2.33. As Hull writes, "The FRTB is proposing a change to the measure used for determining market risk capital. Instead of VaR with a 99% confidence level, expected shortfall (ES) with a 97.5% confidence level is proposed. For normal distributions, the two measures are almost exactly equivalent.[2]"

As an aside, note the Dowd's expression (which tends to be more familiar) also works but requires the normal pdf and inverse CDF; for example, in Excel: normal 97.5% ES = NORM.S.DIST(NORM.S.INV(0.975),FALSE)/(1-0.975) = 2.337803.

[1] Kevin Dowd, Measuring Market Risk, 2nd Edition (West Sussex, England: John Wiley & Sons, 2005)
[2] John Hull, Risk Management and Financial Institutions, 4th Edition (New York: John Wiley & Sons, 2012)

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P2.T7.608.2

In the past, the boundary between the regulatory banking book and the trading book created an opportunity for regulatory arbitrage. As Hull writes, "The FRTB [Fundamental Review of the Trading Book] also addresses the issue of whether instruments should be put in the trading book or in the banking book. Roughly speaking, the trading book consists of instruments that the bank intends to trade. The banking book consists of instruments that are expected to be held to maturity. Instruments in the trading book are marked to market (i.e., revalued) daily while instruments in the banking book are not. Instruments in the banking book are subject to credit risk capital while those in the trading book are subject to market risk capital."[1] Which of the following is **TRUE** about the treatment of the boundary in the FRTB?

A. The FRTB simply collapses the regulatory banking and trading book into a single book which solves the regulatory arbitrage problem

B. The FRTB makes no change to the boundary between the regulatory banking and trading book but subjects both books to the same exact calculations for the capital requirement

C. The FRTB establishes a more objective boundary between the regulatory banking and trading book, including the assignment when a position is initiated and strict limits on subsequent movement between the books

D. The FRTB says that the necessary and sufficient condition for an instrument's inclusion in the trading book is a sincere "intent to trade;" if the position is moved from one book to another, the FRTB imposes the incremental risk capital (IRC) charge as a penalty

C is CORRECT.

The FRTB establishes a more objective boundary between the regulatory banking and trading book, including the assignment when a position is initiated and strict limits on subsequent movement between the books.

[1] John Hull, Risk Management and Financial Institutions, 4th Edition (New York: John Wiley & Sons, 2012)

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P2.T7.609.1

A key difference between the internal models approach (IMA) under Basel I and II.5 and the Fundamental Review of the Trading Book (FRTB)[1] is the introduction of liquidity horizons: while the Basel I and II.5 calculated market risk capital using a 10-day time horizon, the FRTB uses five different horizons (10, 20, 60, 120, and 250 days) depending on the liquidity of the market variable. For example, investment-grade corporate credit spreads and non-investment-grade sovereign credit spreads are each Category 3 Variables with an assigned time horizon of 60 days. Due to this, the FRTB requires calculation of ES(1), ES(2), ES(3), ES(4), and ES(5).

Which of the following best summarizes the approach proposed in the Fundamental Review of the Trading Book (FRTB)[1] for the estimation of expected shortfall (ES)?

A. ES(3) is a 10-day shock to all variables in categories 3, 4, and 5 while holding constant categories 1 and 2. Then ES(3)*sqrt(60/10) scales to a 60-day ES for the category variable. For the simulation, total ES is the square root of the sum of the five squared n-day expected shortfalls (ESs). Five simulations constitute the trial. Finally, 250 overlapping trials (each of the five simulations) are generated to produce the historical simulation.

B. ES(3) is a 10-day shock to all variables in categories 3, 4, and 5 while holding constant categories 1 and 2. Then ES(3)*sqrt(60/10) scales to a 60-day ES for the category variable. For the simulation, total ES is the sum of the five squared n-day expected shortfalls (ESs) because the variable changes are assumed to be perfectly correlated, which is the most conservative assumption. Five simulations constitute the trial. Finally, 250 overlapping trials (each of the five simulations) are generated to produce the historical simulation.

C. ES(3) is a 60-day shock to the variable in category 3, while each variable is shocked over its own liquidity time horizon; e.g., ES(4) in the first trial is a shock equal to the change between Day 0 and Day 120. As ES(1) to ES(5) do not here require scaling, total ES is the square root of the sum of the five ES(n). Each trial is one simulation. Finally, 250 overlapping trials (each of the five simulations) are generated to produce the historical simulation.

D. ES(3) is a 60-day shock to the variable in category 3, while each variable is shocked over its own liquidity time horizon; e.g., ES(4) in the first trial is a shock equal to the change between Day 0 and Day 120. As ES(1) to ES(5) do not here require scaling, total ES for the simulation is the sum of the five ES(n)^2 because the variable changes are assumed to be perfectly correlated, which is the most conservative assumption. Five simulations constitute the trial. Finally, 250 overlapping trials (each of the five simulations) are generated to produce the historical simulation.

A is CORRECT.

ES(3) is a 10-day shock to all variables in categories 3, 4, and 5 while holding constant categories 1 and 2. Then ES(3)*sqrt(60/10) scales to a 60-day ES for the category variable. For the simulation, total ES is the square root of the sum of the five squared n-day expected shortfalls (ESs). Five simulations constitute the trial. Finally, 250 overlapping trials (each of the five simulations) are generated to produce the historical simulation.

[1] John Hull, Risk Management and Financial Institutions, 4th Edition (New York: John Wiley & Sons, 2012)

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P2.T7.609.2

Each of the following is true about the internal models-based approach (IMA) under the Fundamental Review of the Trading Book (FRTB)[1] **EXCEPT,** which is false?

A. The FRTB, therefore, allows the stressed period calculations to be based on a SUBSET of market variables which are scaled up if the subset of market variables account for at least 75% of the expected shortfall

B. The backtest must be conducted of the 97.5% stressed expected shortfall (ES) measure; that is, just as FRTB switches from Basel I/II.5's 99.0% value at risk (VaR) to 97.5% ES, the backtest must use the same stressed ES measure

C. Although the use of overlapping time periods is less than ideal because changes in successive historical simulation trials are not independent, this does not bias the results but instead reduces the effective sample size making results more noisy than they would otherwise be

D. The capital charge is based on a weighted average of (a) the expected shortfall for the whole portfolio and (b) the sum of the partial expected shortfalls. The partial expected shortfalls are determined by shocking the variables in a risk category (i.e., interest rate risk, equity risk, foreign exchange risk, commodity risk, and credit risk) while keeping all other variables fixed

B is CORRECT.

It is not possible to backtest stressed VaR/ES. Further, backtesting 10-day ES is difficult. For these reasons, the backtest under FRTB still uses the value at risk (VaR) measure.

According to Minimum capital requirements for market risk (January 2016), ***"5.183.(c).*** Backtesting requirements are based on comparing each desk's 1-day static value-at-risk measure (calibrated to the most recent 12 months' data, equally weighted) at both the 97.5th percentile and the 99th percentile, using at least one year of current observations of the desk's one-day P&L.38 If any given desk experiences either more than 12 exceptions at the 99th percentile or 30 exceptions at the 97.5th percentile in the most recent 12-month period, all of its positions must be capitalised using the standardised approach.39 Positions must continue to be capitalised using the standardised method until the desk no longer exceeds the above thresholds over the prior 12 months."[2]

[1] John Hull, Risk Management and Financial Institutions, 4th Edition (New York: John Wiley & Sons, 2012)

[2] Basel Committee on Banking Supervision, "Minimum capital requirements for market risk" 2016 (https://www.bis.org/bcbs/publ/d352.htm)

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P2.T7.609. 3

Basel II.5 introduced the incremental risk charge (IRC) to ensure that banks did not reduce capital requirements by choosing the trading book over the banking book for a credit-dependent instrument, aka regulatory arbitrage. How does the Fundamental Review of the Trading Book (FRTB)[1] address credit trades?

A. The FRTB makes no changes to the IRC

B. The FRTB edits the IRC to produce a capital charge based on a 10-day, 97.5% confident expected shortfall (ES)

C. The FRTB replaces IRC with the default risk charge (DRC), which recognizes jump-to-default risk and mandates the inclusion of equity products

D. The FRTB replaces IRC with the default risk charge (DRC), which does not recognize jump-to-default risk and explicitly excludes equity products

C is CORRECT.

The FRTB replaces IRC with the default risk charge (DRC), which recognizes jump-to-default risk and mandates the inclusion of equity products

[1] John Hull, Risk Management and Financial Institutions, 4th Edition (New York: John Wiley & Sons, 2012)

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P2.T7.20.4.1

Peter is a risk analyst who seeks to validate his bank's default probability (PD) estimates. His bank's large historical sample includes several years of PD estimates and the actual (aka, observed) default rates. As De Laurentis writes, *"validating calibration means analyzing differences between forecasted PDs and realized default rates."*[1] In regard to possible credit rating validation methodologies, each of the following statements is true **EXCEPT,** which is false?

A. The binomial test can be applied to one rating category at a time, but it assumes independence of default events

B. The chi-square test can be used to check several rating categories simultaneously but assumes independence and a normal approximation

C. The normal test is a multi-period test of a default probability forecast for a single rating category that allows for cross-sectional dependence

D. The traffic lights approach cannot be applied to the validation of PD estimates because it is designed for the backtest of value at risk (VaR) models

D is CORRECT.

False because the traffic light approach is indeed usable to validate PD estimates!

From the Studies on the Validation of Internal Rating Systems, Basel Committee on Banking Supervision, Working Paper No. 14 (**emphasis ours**):

"The concept of a traffic lights approach can be transferred to the validation of PD estimates. However, it is unlikely that direct consequences for the capital requirements of a bank can be derived from this approach. A recently proposed version of a traffic lights approach is – in contrast to the normal test – completely independent of any assumption of constant or nearly constant PDs over time. It can be considered as a multi-period backtesting tool for a single rating category that is based on the assumption of cross-sectional and inter-temporal independence of default events. The distribution of the number of defaults in one year is approximated with a normal distribution. Based on the quantiles of this normal distribution, the number of defaults is mapped to one of the four traffic light colours: green, yellow, orange, and red. This mapping results in a multinomial distribution of the numbers of colours when observed over time. Inference on the adequacy of default probability forecasts this way becomes feasible ...

In conclusion, **at present no really powerful tests of adequate calibration are currently available. Due to the correlation effects that have to be respected there even seems to be no way to develop such tests.** Existing tests are rather conservative – such as the binomial test and the chi-square test – or will only detect the most obvious cases of miscalibration as in the case of the normal test. As long as validation of default probabilities per rating category is required, **the traffic lights testing procedure appears to be a promising tool** because it can be applied in nearly every situation that might occur in practice. Nevertheless, it should be emphasised that there is no methodology to fit all situations that might occur in the validation process. Depending on the specific circumstances, the composition of a mixture of different techniques will be the most appropriate way to tackle the validation exercise."[2]

In regard to (A), (B), and (C), each is TRUE.

- **The binomial test** can be applied to one rating category at a time, but it assumes independence of default events
- **The chi-square test** can be used to check several rating categories simultaneously but assumes independence and a normal approximation
- **The normal test** is a multi-period test of a default probability forecast for a single rating category that allows for cross-sectional dependence

[1] Giacomo De Laurentis, Renato Maino, Luca Molteni, Developing, Validating and Using Internal Ratings (Hoboken, NJ: John Wiley & Sons, 2010)
[2] Studies on the Validation of Internal Rating Systems, Basel Committee on Banking Supervision, Working Paper 14 https://www.bis.org/publ/bcbs_wp14.htm. Note that BIS allows reproduction of limited extracts (up to 400 words of text, or two tables not exceeding 10% of publication per their terms at https://www.bis.org/terms_conditions.htm#Copyright_and_Permissions

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P2.T7.20.4.2

Consider the credit rating migration matrix below:

	AAA	AA	A	BBB	BB	B	CCC to C	D
AAA	91.00	9.00	-	-	-	-	-	-
AA	1.00	84.00	1.00	5.00	9.00	-	-	-
A	0.40	2.00	91.60	3.00	2.00	1.00	-	-
BBB	-	0.60	2.00	88.50	5.00	3.00	0.90	-
BB	-	0.40	1.00	3.00	79.60	10.00	4.00	2.00
B	-	-	0.80	3.00	9.00	67.20	9.00	11.00
CCC - C	-	-	-	2.00	10.00	15.00	58.00	15.00
Default (D)	-	-	-	-	-	-	-	100.00

This matrix contains an abnormality (i.e., a property that is not desirable). Where is the abnormality?

A. The AA row contains an abnormality

B. The diagonal contains an abnormality

C. The BBB row contains an abnormality

D. The default column, (D), contains an abnormality

A is CORRECT.

A three-minus class migration should not be greater than a two-minus class migration should not be greater than a one-class migration.

	AAA	AA	A	BBB	BB	B	CCC to C	D
AAA	91.00	9.00	-	-	-	-	-	-
AA	1.00	84.00	1.00	5.00	9.00	-	-	-
A	0.40	2.00	91.60	3.00	2.00	1.00	-	-
BBB	-	0.60	2.00	88.50	5.00	3.00	0.90	-
BB	-	0.40	1.00	3.00	79.60	10.00	4.00	2.00
B	-	-	0.80	3.00	9.00	67.20	9.00	11.00
CCC - C	-	-	-	2.00	10.00	15.00	58.00	15.00
Default (D)	-	-	-	-	-	-	-	100.00