FINM 36700 — Midterm

Portfolio and Risk Management

Autumn 2026

Name: _____

UChicago ID: _____

- This exam is **closed book** and **closed notes**. No calculator or other electronics.
- Questions marked † **[Select All That Apply]** may have zero, one, or more correct choices. Mark every correct choice, and leave the question blank if none is correct. Full credit requires exactly the correct set; otherwise the question earns zero.
- All other questions have exactly one correct choice.

Question type	**Questions**	**Points each**	**Points**
Single-select	35	2	70
Multiple-select (†)	27	2	54
Total	**62**		**124**

Returns and performance

Exhibit 1: Two fund histories Hypothetical annualized sample statistics over the same dates. Means are arithmetic total returns. The risk-free return is a constant 3% per year; borrowing and lending use that rate. Maximum drawdown is measured over the complete sample, not annualized.

Fund	Mean	Volatility	Maximum drawdown
A	9%	10%	-38%
B	12%	20%	-24%

1. Using Exhibit 1, an investor scales Fund A with borrowing to match Fund B's 12% mean total return. Ignoring borrowing constraints, what annualized volatility does that scaled investment have?

- **A.** 13.3%
- **B.** 15%
- **C.** 18%
- **D.** 20%
- **E.** 30%

2. † **[Select All That Apply]** Which conclusions about Exhibit 1 are correct?

☐ **A.** Fund B has the higher Sharpe ratio because its total mean is higher.
☐ **B.** Fund A has the higher Sharpe ratio once the 3% risk-free return is subtracted.
☐ **C.** An equal-weight mix of A and B has volatility above 15%.
☐ **D.** The maximum-drawdown comparison and the Sharpe-ratio comparison favor different funds.
☐ **E.** Subtracting the 3% risk-free return changes each fund's mean but not its volatility.

Exhibit 2: Two investment paths Hypothetical wealth from an initial investment of 100, with no deposits, withdrawals, fees, or distributions outside the account. The intervals have equal length.

Date	Path A	Path B
0	100.00	100.00
1	120.00	120.00
2	96.00	144.00
3	115.20	115.20
4	92.16	92.16

3. † **[Select All That Apply]** Which statistics are identical for Paths A and B in Exhibit 2?

☐ **A.** The arithmetic mean of the four simple returns.
☐ **B.** The standard deviation of the four simple returns.
☐ **C.** The sum of the four log returns.
☐ **D.** The maximum drawdown.
☐ **E.** The worst single-interval simple return.

4. Over one year, a portfolio earns a 6% nominal total return, a Treasury bill earns 4%, and inflation is 5%. Which pair correctly describes the portfolio's excess return and its approximate real return?

- **A.** 2% excess; 1% real.
- **B.** 1% excess; 2% real.
- **C.** 2% excess; 6% real.
- **D.** 6% excess; 1% real.
- **E.** 2% excess; -3% real.

5. A performance report lists a monthly mean excess return of 1%, a monthly standard deviation of 4%, and an annualized Sharpe ratio of 3.0. Under the usual no-serial-correlation annualization, which error produced the 3.0?

- **A.** Both the mean and the standard deviation were annualized by 12.
- **B.** The mean was annualized by 12 and the standard deviation by the square root of 12.
- **C.** Both the mean and the standard deviation were annualized by the square root of 12.
- **D.** The mean was annualized by the square root of 12 and the standard deviation by 12.
- **E.** The mean was annualized by 12, but the standard deviation was left monthly.

6. † **[Select All That Apply]** Which statements about analyzing a stock index's history are correct?

- ☐ **A.** Returns are analyzed rather than price levels because a price series is not stationary: its sample mean and variance do not estimate stable quantities.
- ☐ **B.** Weekly index returns are close to serially uncorrelated, so last week's return says little about the sign of this week's.
- ☐ **C.** The clearest failure of the IID assumption is in volatility: calm and turbulent periods cluster, so the variance is not constant over time.
- ☐ **D.** Normality is assumed because daily returns support it; the assumption breaks down only when returns are aggregated to monthly frequency.
- ☐ **E.** Converting prices to returns removes the clustering of volatility, so a single historical variance describes every period equally well.

7. Where does the normal model for an equity index's returns fail most clearly?

- **A.** In the tails, and more at daily than at monthly frequency: the most extreme standardized daily moves lie far beyond anything a normal distribution allows, while monthly extremes are much milder.
- **B.** At every quantile about equally, because the sample mean and variance do not characterize the data at any horizon.
- **C.** In the center of the distribution: the histogram of monthly index returns is visibly asymmetric and flat around its mean.
- **D.** At monthly more than daily frequency, because aggregating daily returns over a month compounds the extreme days.
- **E.** Only in the positive tail, since large gains are rarer under normality than large losses of the same size.

8. † **[Select All That Apply]** Which of these return streams would you expect to be positively skewed?

- ☐ **A.** A diversified equity index, which tends to rise gradually and fall sharply.
- ☐ **B.** A venture portfolio of twenty start-ups in which a few large successes carry the fund.
- ☐ **C.** A strategy that sells insurance against market crashes and collects premiums in calm years.
- ☐ **D.** A long position in far out-of-the-money call options that usually expire worthless.
- ☐ **E.** Bitcoin, because its volatility is several times that of an equity index.

9. Over the same sample a high-yield bond ETF has a Sharpe ratio of 0.30 and an information ratio of -0.46 relative to the equity market. What does the combination tell an investor who already holds the market?

- **A.** The ETF improves the portfolio because its Sharpe ratio is positive; once the market is already held, the information ratio carries no additional information.
- **B.** Its sample alpha on the market is negative, so a small long addition lowers a market holding's in-sample Sharpe ratio even though the ETF's own excess mean is positive.
- **C.** The two ratios are inconsistent: a positive Sharpe ratio implies a positive alpha against a benchmark that itself has a positive premium.
- **D.** The information ratio is negative only because it uses total rather than excess returns in its numerator, so it understates the ETF's performance.
- **E.** The ETF is a useful hedge for the market, because a negative information ratio means its residual return moves against the market's return.

Portfolio allocation

Exhibit 3: Two assets Hypothetical annual excess returns on two assets, with parameters treated as known. Returns are in excess of a risk-free asset that can be held long or short without limit.

Asset	Mean excess return	Volatility	Correlation with the other asset
1	8%	20%	0.5
2	4%	20%	0.5

10. In Exhibit 3, without computing it exactly, which range contains the volatility of a portfolio with 50% in each asset, and why?

- **A.** Exactly 20%, because both assets have 20% volatility and the weights sum to one.
- **B.** Exactly 10%, because each asset's 20% volatility is halved by its 50% weight.
- **C.** Between 14.1% and 20%, because the correlation of 0.5 lies between zero and one.
- **D.** Below 14.1%, because a correlation of 0.5 removes more than half of the variance.
- **E.** Exactly 14.1%, because each 50% weight adds a quarter of its asset's variance.

11. Regress asset 2's excess return on asset 1's excess return in Exhibit 3. What is asset 2's alpha, and what does it imply for asset 2's weight in the tangency portfolio?

- **A.** Alpha is zero, but asset 2 receives a positive weight because its Sharpe ratio is positive.
- **B.** Alpha is 4%, and asset 2 receives a positive weight.
- **C.** Alpha is -4%, and asset 2 is shorted.
- **D.** Alpha is zero, and asset 2 receives the same weight as asset 1 because the volatilities are equal.
- **E.** Alpha is zero, and asset 2 receives zero weight.

12. † **[Select All That Apply]** An investor holds \$1 of asset 2 in Exhibit 3 and hedges the exposure to asset 1 with the regression hedge. Which statements are correct?

- ☐ **A.** The hedge shorts \$0.50 of asset 1 per \$1 of asset 2.
- ☐ **B.** The hedged position's expected excess return equals asset 2's alpha on asset 1.
- ☐ **C.** The hedged position has zero volatility.
- ☐ **D.** A dollar-for-dollar hedge, short \$1.00 of asset 1, would leave the position with negative exposure to asset 1.
- ☐ **E.** The hedge removes half of asset 2's variance, since the correlation with asset 1 is 0.5.

Exhibit 4: Harvard ETF allocation exercise Monthly ETF excess returns, February 2011–July 2026; SHV is subtracted and QAI is excluded. Each allocation is scaled to a 1% monthly sample mean excess return. The table annualizes means by 12 and volatilities by the square root of 12. All rows are evaluated using the same original sample covariance matrix. Shorting and borrowing are allowed. Before scaling, the equal-weight portfolio (10% in each ETF) has an annualized mean excess return of 4.3% and volatility 9.9%.

Allocation	Mean excess return	Volatility
Tangency	12.0%	8.1%
Equal weight	12.0%	27.5%
Inverse variance	12.0%	32.6%
Regularized	12.0%	10.5%

13. Why is the tangency portfolio's lower volatility than the regularized portfolio in Exhibit 4 unsurprising?

- **A.** The regularized portfolio is required by its construction to hold more risky assets than the tangency portfolio.
- **B.** The table evaluates each portfolio with its own covariance estimate rather than a common one.
- **C.** Shrinking the covariances raises the regularized portfolio's realized sample volatility by construction.
- **D.** The sample covariance matrix was estimated accurately enough that shrinking it only discarded information.
- **E.** Tangency weights maximize the in-sample Sharpe ratio; at a common mean, nothing has lower in-sample volatility.

14. † **[Select All That Apply]** Which interpretations of Exhibit 4 are correct?

- ☐ **A.** The common 12% mean is imposed by rescaling, not evidence that the methods forecast the same return.
- ☐ **B.** The inverse-variance rule uses the cross-asset covariances when assigning its relative weights across assets.
- ☐ **C.** The equal-weight row holds equal risky weights that sum to more than one after scaling; borrowing finances the difference.
- ☐ **D.** At the common mean, inverse variance has the lowest Sharpe ratio of the four allocations.
- ☐ **E.** Inverse variance tilts toward the lower-volatility ETFs, yet at the common mean it has more volatility than equal weight.

15. For an unconstrained risky portfolio, $w \propto \Sigma^{-1}\mu^e$. If all expected excess returns are multiplied by the same positive constant, with covariance unchanged, what happens to the risky weights normalized to sum to one? Assume the original normalization is well defined.

- **A.** Every normalized weight is multiplied by that constant.
- **B.** They become equal weights.
- **C.** Every short position becomes a long position.
- **D.** They are unchanged.
- **E.** They tilt further toward the highest-mean assets.

Exhibit 5: A covariance estimate before and after shrinkage Hypothetical annual covariance estimates for assets X and Y, using returns as decimals. The rule is $\widehat{\Sigma} = (\Sigma + \text{diag}(\Sigma))/2$. Expected excess returns are unchanged.

Entry	Original	Regularized
Variance of X	0.040	0.040
Variance of Y	0.010	0.010
Covariance of X and Y	0.012	0.006

16. † **[Select All That Apply]** An optimizer produces large offsetting long and short positions. Which statements about regularizing its covariance input with the rule in Exhibit 5 are correct?

- ☐ **A.** It shrinks each covariance toward zero and leaves each variance unchanged.
- ☐ **B.** For a position long \$1 of X and short \$1 of Y, it raises the estimated portfolio variance, because it shrinks a positive covariance that was offsetting part of that position's risk.
- ☐ **C.** It is equivalent to prohibiting short positions.
- ☐ **D.** It multiplies every optimal weight by one half.
- ☐ **E.** It would still improve the weights if the covariance matrix were known rather than estimated.

Exhibit 6: Harvard TIPS sensitivity The same monthly excess returns as Exhibit 4: February 2011–July 2026, 186 months, ten ETFs with QAI excluded. TIP is the TIPS ETF. Its annualized mean excess return is 1.3%, its volatility 5.0%, and its Sharpe ratio 0.26; its correlation is 0.76 with IEF and 0.39 with SPY. The standard error of TIP's monthly sample mean is about 0.11%. Tangency weights are normalized to sum to one; shorting is allowed.

Case	TIP weight in the tangency portfolio	Tangency Sharpe ratio, annualized
Baseline sample	-19%	1.48
TIP removed from the investment set	none	1.47
TIP's monthly mean raised by 0.12%	+126%	1.57

17. † **[Select All That Apply]** Which conclusions does Exhibit 6 support?

- ☐ **A.** Because TIPS' standalone Sharpe ratio is below the tangency portfolio's, the optimizer shorts them.
- ☐ **B.** Removing TIPS barely changes the best attainable Sharpe ratio, so TIPS add little to the estimated opportunity set.
- ☐ **C.** A change in the TIPS mean of about one standard error moves the TIPS weight from a short to a large long position.
- ☐ **D.** TIPS are nearly uncorrelated with the other assets, which is why removing them changes the Sharpe ratio so little.
- ☐ **E.** TIP is shorted in the baseline even though its sample mean excess return is positive.

18. In Exhibit 6 the TIP weight moves from -19% to +126% while the tangency Sharpe ratio moves only from 1.48 to 1.57. Which statement explains the contrast?

- **A.** The Sharpe ratio is insensitive to the mean inputs, so only the weights carry the information that the data hold about TIPS.
- **B.** The inverse covariance matrix turns a small change in one mean into large offsetting positions among correlated assets, while the attainable Sharpe ratio moves little.
- **C.** The weight change is an artifact of normalizing the weights to sum to one, which magnifies small differences between the cases.
- **D.** The weight swing means the covariance estimate must have changed between the cases, since changing the means alone cannot move weights that much.
- **E.** The optimizer treats the 0.12% as certain, while the Sharpe ratio discounts it for the sampling error in TIP's mean.

19. An analyst estimates the inputs of a mean-variance optimization from 50 years of monthly index returns; the annual volatility is about 16%. Which statement about the precision of the inputs is correct?

- **A.** The volatility is the hard input: with 600 monthly observations its standard error is larger than that of the mean return.
- **B.** Both inputs are estimated to within a fraction of a percent per year, because 600 monthly observations is a large sample by the usual standards.
- **C.** The expected return is estimated well because the sample is long, so disagreement among investors about it reflects views on the future rather than on the data.
- **D.** The expected return is the hard input: its standard error is about 16% over the square root of 50 years, roughly 2 points per year, large relative to plausible premia.
- **E.** Neither input is usefully estimated from history, because price levels are not stationary and returns inherit that problem.

20. Mean-variance investors share the same estimates of means and covariances and can borrow and lend at the risk-free rate, but differ in risk aversion. How do their portfolios differ?

- **A.** They hold the same risky portfolio in different amounts, combining it with more or less of the risk-free asset.
- **B.** They hold different risky portfolios: the more risk-averse tilt toward lower-volatility assets within their risky holdings.
- **C.** They hold the same total amount in risky assets but choose different points along the risky-only frontier.
- **D.** They differ only in leverage; a more risk-averse investor shorts the tangency portfolio to reduce risk.
- **E.** They cannot be compared, because the tangency portfolio is defined only for a given level of risk aversion.

Exhibit 7: Unconstrained stock allocation Selected rows from the assigned 10-stock-plus-SPY optimization, using weekly returns from July 10, 2015–June 26, 2026. As permitted in that exercise, the risk-free rate is set to zero. The full weight vector sums to 100%; its sum of absolute weights is 1,007.5%. Ratios are annualized using 52 weeks. Values below are rounded; omitted stocks account for the remaining positions. Correlation with SPY: BRK/B 0.70, NVDA 0.64, LLY 0.34. BRK/B's correlations with the other nine stocks run from 0.20 to 0.41. BRK/B has the lowest annualized mean of the ten stocks (13.5%); its ratio of 0.716 is the second lowest after META (0.649).

Asset	Optimized weight	Mean/volatility
BRK/B	169.6%	0.716
LLY	90.5%	1.011
NVDA	84.6%	1.420
SPY	-453.8%	0.859

21. Use Exhibit 7's SPY weight at the beginning of a hypothetical week in which SPY gains 1%. What is the SPY position's contribution to the full portfolio's return, expressed relative to the investor's beginning capital? Ignore financing and trading costs.

- **A.** Approximately +4.54 percentage points.
- **B.** Approximately -0.0454 percentage point.
- **C.** Approximately -0.45 percentage point.
- **D.** Approximately -1.00 percentage point.
- **E.** Approximately -4.54 percentage points.

22. † **[Select All That Apply]** Which readings of Exhibit 7 are correct?

- ☐ **A.** A 100% net weight means the portfolio uses no leverage.
- ☐ **B.** The gross exposure is about ten times the investor's capital despite a 100% net allocation.
- ☐ **C.** NVDA has the largest weight of the ten stocks because it has the largest ratio.
- ☐ **D.** The BRK/B and NVDA comparison shows that standalone ratios alone do not determine optimized weights.
- ☐ **E.** SPY is shorted because it has the lowest mean/volatility ratio of the eleven assets.

23. Why does the optimizer in Exhibit 7 hold about 170% in BRK/B, the stock with the second-lowest mean/volatility ratio of the ten?

- **A.** BRK/B has the highest mean return among the lower-volatility stocks in the set, which the optimizer rewards.
- **B.** BRK/B's relatively high correlation with SPY helps offset the market short, while its weaker correlations with the other stocks add diversification.
- **C.** The optimizer weights stocks by inverse variance, and BRK/B has the lowest variance of the ten stocks.
- **D.** BRK/B's ratio is understated because its returns are total rather than excess returns, unlike the others.
- **E.** With SPY shorted about 454%, BRK/B's weight is the residual that brings the net allocation back to 100%.

24. † **[Select All That Apply]** A portfolio's unconstrained optimum shorts domestic equities. A long-only optimization on the same inputs instead assigns domestic equities zero. Which conclusions are correct?

☐ **A.** The zero weight is consistent with a binding lower bound.
☐ **B.** The equity asset has a negative expected excess return.
☐ **C.** Tightening allocation bounds leaves the other assets' weights unchanged when their expected returns are unchanged.
☐ **D.** The equity asset has zero covariance with the remaining assets, which is why its constrained weight is zero.
☐ **E.** On the same inputs, the long-only portfolio's in-sample Sharpe ratio is at most the unconstrained optimum's.

Decomposition, hedging, and replication

Exhibit 8: A one-factor decomposition Hypothetical OLS regression with an intercept: $r^e_F = \alpha + \beta r^e_M + \epsilon$. All moments use the same observations. Returns are excess returns. Means and volatilities below are annualized consistently; the sample residual is orthogonal to the market.

Quantity	Value
Fund mean / volatility	14% / 20%
Market mean / volatility	6% / 8%
Market beta, β	2.0
Centered R^2	0.64

25. † **[Select All That Apply]** Which statements follow from Exhibit 8's in-sample OLS decomposition?

☐ **A.** The fund's alpha is 2% per year.
☐ **B.** Market exposure accounts for 64% of the fund's variance, not 64% of its standard deviation.
☐ **C.** A beta-neutral fund-minus-market strategy retains residual risk.
☐ **D.** The alpha can be earned by itself, without holding the residual risk.
☐ **E.** The fund's information ratio is 2% over 20%, or 0.10.

26. An investor who already holds the market portfolio considers adding the fund in Exhibit 8. Treat the exhibit's sample moments as expected inputs, and allow the market and risk-free positions to be adjusted freely. Which statement is correct?

- **A.** The fund cannot improve on holding the market alone, because its own Sharpe ratio (0.70) is below the market's Sharpe ratio (0.75).
- **B.** Hedging out the fund's market exposure leaves a position whose Sharpe ratio equals the fund's own Sharpe ratio of 0.70, since hedging removes only risk.
- **C.** The fund improves the portfolio only if its R-squared on the market is below one half, so that more than half of its risk is residual.
- **D.** A small long position in the fund, with the market position adjusted, raises the attainable Sharpe ratio, because the fund's alpha on the market is positive.
- **E.** The fund improves the portfolio only if its information ratio exceeds the market's Sharpe ratio of 0.75, which it does not.

Exhibit 9: ProShares case: the hedge-fund series Monthly returns from the assigned ProShares workbook, August 2011–August 2025: the 169 months in which every series is observed (HFRI's September 2025 value is missing). Returns are used as given in the assignment, not converted to excess returns. Means, volatilities, and alphas are annualized; the Sharpe ratio is mean divided by volatility. Each series is regressed on SPY with an intercept. MLFM-ES is the tradable Merrill Lynch factor index that HDG tracks; the correlation between HDG and MLFM-ES is 0.99.

Series	Mean	Volatility	Sharpe	Beta on SPY	Alpha on SPY	R^2	Corr. with HFRI
HFRI	5.1%	5.9%	0.87	0.35	0.2%	0.72	1.00
MLFM-ES	3.6%	5.5%	0.65	0.34	-1.3%	0.79	0.90
HDG	2.6%	5.7%	0.45	0.35	-2.4%	0.77	0.89
QAI	2.8%	5.0%	0.56	0.30	-1.5%	0.75	0.86
SPY	14.3%	14.4%	1.00	1.00	0.0%	1.00	0.85

27. Every hedge-fund series in Exhibit 9 has a SPY beta near 0.35 and an R-squared near 0.75. HFRI's Sharpe ratio is 0.87 and HDG's is 0.45. Which statement best accounts for the gap?

- **A.** HDG carries more market risk per dollar invested than HFRI does, which lowers its ratio.
- **B.** HDG's alpha on SPY is negative while HFRI's is near zero; the gap is in mean return, not systematic risk.
- **C.** HDG's volatility is much higher than HFRI's, which lowers its ratio for the same mean.
- **D.** HDG is weakly correlated with HFRI, so it tracks a different set of risks with a lower premium.
- **E.** HDG's higher R-squared (0.77 against 0.72) leaves less residual return, the source of HFRI's extra mean.

Exhibit 10: ProShares case: replicating HFRI Regression of HFRI on the six Merrill factors over the same 169 months as Exhibit 9, with and without an intercept. Coefficients are the fitted positions per dollar of HFRI; factor positions exclude the fitted intercept. For this exercise, treat the supplied T-bill proxy as an investable cash-return series. The intercept is annualized. Tracking error is the annualized volatility of the residual.

Quantity	With intercept	Without intercept
Coefficient on SPY	0.04	0.06
Coefficient on the 3-month T-bill factor	0.32	0.65
Coefficient on EEM	0.09	0.08
Coefficient on EFA	0.07	0.07
Coefficient on EUO	0.03	0.03
Coefficient on IWM	0.15	0.14
Sum of absolute coefficients	0.70	1.03
Intercept, annualized	1.4%	none
R^2	0.84	—
Mean of the fitted series, annualized	5.1%	4.4%
Correlation of the fitted series with HFRI	0.92	0.92
Tracking error, annualized	2.3%	2.3%

28. † **[Select All That Apply]** Which statements about the replication in Exhibit 10 are correct?

- ☐ **A.** The with-intercept factor positions have a gross size of about 0.70 per dollar of HFRI, so they can be held without leverage or large short positions.
- ☐ **B.** Removing the intercept leaves the fitted series' correlation with HFRI at about 0.92 at the printed precision but lowers its mean below HFRI's mean.
- ☐ **C.** With an intercept, the fitted series (intercept included) has the same sample mean as HFRI by construction.
- ☐ **D.** A tracking error of 2.3% per year bounds the replication's annual return within 2.3 percentage points of HFRI's.
- ☐ **E.** The factor positions alone, excluding the intercept, earned about 3.7% per year over the sample.

29. When the intercept is removed in Exhibit 10, the T-bill coefficient rises from 0.32 to 0.65 while the other five coefficients barely move. Why?

- **A.** The T-bill factor is the regressor most highly correlated with HFRI, so it gains weight.
- **B.** Without an intercept, least squares forces the coefficients to sum to one, and the T-bill fills the gap.
- **C.** Removing the intercept raises the fitted mean, and a larger T-bill position offsets the increase.
- **D.** The T-bill return has very low volatility relative to the other factors, so it absorbs the level the intercept had carried.
- **E.** The T-bill factor is the most collinear of the six regressors, so its coefficient is the least stable across specifications.

30. A replicator must decide whether to include an intercept when fitting tradable factor positions to a target's returns. When is it better to leave the intercept out?

- **A.** When the target's in-sample mean is trusted to persist, so the positions should match the level of returns as well as the co-movement.
- **B.** When the target's in-sample mean is not trusted to persist, because dropping the intercept stops the positions from chasing that mean.
- **C.** If the R-squared of the regression with an intercept is below 0.9, because the fit then needs the extra freedom.
- **D.** If the regression's residuals have a nonzero sample mean, because an intercept is then needed to absorb it.
- **E.** When the replication must be tradable, since an intercept is not a position that can be held.

Exhibit 11: Decomposing Apollo returns Weekly excess returns, January 9, 2015–October 3, 2025, from the assigned private-equity data. Both OLS regressions include an intercept and use the same 561 observations. SPY, IEF, and HYG are traded ETF returns. Alpha and residual volatility are annualized using 52 weeks. This is a descriptive decomposition.

Model	Alpha	SPY beta	IEF beta	HYG beta	R^2	Residual vol.
SPY only	4.9%	1.480	—	—	0.466	26.9%
Three ETFs	10.0%	1.066	-0.704	0.931	0.497	26.1%

31. † **[Select All That Apply]** Which interpretations of Exhibit 11 are correct?

- ☐ **A.** The three-ETF regression explains somewhat more of APO's weekly variation in this sample.
- ☐ **B.** Adding regressors moves the fitted intercept toward zero.
- ☐ **C.** The SPY coefficient changes because it is now a partial exposure, holding the other included factors fixed.
- ☐ **D.** The larger intercept means APO's manager added more value in the three-factor sample.
- ☐ **E.** The SPY-only beta of 1.480 is APO's correlation with SPY scaled by APO's volatility over SPY's.

32. † **[Select All That Apply]** An investor holds $1 of APO and wants to remove the fitted three-ETF exposures in Exhibit 11. Adjust the risk-free position to keep net investment at $1. Ignore trading costs and estimation error. Which statements are correct?

- ☐ **A.** The IEF hedge is a short position because APO's estimated IEF coefficient is negative.
- ☐ **B.** The hedge shorts SPY and HYG and goes long IEF, in the displayed beta magnitudes.
- ☐ **C.** The hedge eliminates the residual variation as well as the fitted ETF component.
- ☐ **D.** The historical hedged excess mean per original $1 of APO is approximately the annual alpha.
- ☐ **E.** Each hedge ratio should come from a separate one-factor regression, such as 1.480 for SPY.

Exhibit 12: A rolling replication record Hypothetical two-factor version of the ProShares exercise. At the end of month 60, a regression with an intercept is fitted using months 1–60. Its coefficients are held fixed for month 61. The displayed month-61 returns become known only at the end of month 61. Both factors and the target are excess returns; ignore trading costs.

Quantity	Value
Estimated monthly intercept	0.10%
Estimated beta on factor 1 / factor 2	0.40 / 0.60
Realized month-61 factor 1 / factor 2 return	5.00% / -1.00%
Realized month-61 target return	1.50%

33. Does using the realized month-61 factor returns in Exhibit 12 make this an invalid out-of-sample replication evaluation?

- **A.** Yes. An out-of-sample test must use the factors' prior sample means in place of their realized returns.
- **B.** Yes. Using any outcome that was unknown when the positions were chosen makes the evaluation in-sample.
- **C.** No. The coefficients were fixed before month 61; the realized factor returns are what those positions earned.
- **D.** No. The month-61 target return may enter the estimation once the procedure is labeled a rolling model.
- **E.** No. Any evaluation that uses realized returns is out of sample, whether or not the coefficients were fixed before the month began.

34. In Exhibit 12, the factor positions earn 1.40% in month 61 and the target earns 1.50%. An analyst adds the estimated 0.10% intercept to the positions' return and reports that the replication matched the target exactly. Which assessment is correct?

- **A.** Correct: because the factor weights sum to one, a cash position finances the intercept and delivers it.
- **B.** Correct: fixing the coefficients before month 61 makes the intercept an earned return for that month, like the factor positions.
- **C.** Incorrect: the fitted intercept is not earned by any traded position, so the positions trail the target by 0.10 percentage points.
- **D.** Incorrect: a positive intercept means the positions beat the target on average, so the month-61 shortfall is noise rather than a gap.
- **E.** Correct: with an intercept the fitted series matches the target's mean by construction, so adding it recovers the target each month.

35. † **[Select All That Apply]** A factor covariance model uses $\Sigma_r = B\Sigma_f B^\top + D$, where D is a diagonal matrix of positive residual variances. Which statements are correct?

- ☐ **A.** The model removes cross-asset residual covariances but retains each asset's residual variance.
- ☐ **B.** The model assumes the total covariance matrix of asset returns is diagonal.
- ☐ **C.** The common factors can produce cross-asset covariance even when D is diagonal.
- ☐ **D.** A diagonal residual covariance matrix makes the residuals statistically independent of one another.
- ☐ **E.** With the factors fixed, the parameter count grows with the number of assets, not with its square.

36. Suppose 100 assets each have beta one to the same factor. Their residuals have equal, positive, finite variance, are mutually uncorrelated, and are uncorrelated with the factor. As equally weighted holdings expand to more such assets, what happens to portfolio risk?

- **A.** Both factor and residual variance fall in proportion to the number of assets.
- **B.** Factor variance falls, while residual variance remains unchanged.
- **C.** Neither component changes, since every asset has the same beta.
- **D.** Residual variance declines, while the common factor component remains.
- **E.** Neither falls, since diversifying residuals needs negative correlation.

37. An analyst proposes a factor covariance model with a diagonal residual covariance matrix, $\Sigma_r = B\Sigma_f B^\top + D$, and treats the high R^2 of each asset's factor regression as sufficient validation of the diagonal restriction. Which assessment is correct?

- **A.** The restriction holds by construction: least squares makes each asset's residuals uncorrelated with the factors, so nothing common remains in them.
- **B.** High R-squared for every asset implies that the residuals are nearly uncorrelated across assets, because little variance is left for them to share.
- **C.** The restriction can be checked by confirming that each asset's residual variance is small relative to its total variance, which is the same information as R-squared.
- **D.** If the factors are uncorrelated with one another, the residuals must be uncorrelated across assets as well, so the restriction holds automatically.
- **E.** High R-squared is not sufficient: the restriction concerns the correlations among the residuals across assets, which must be examined directly.

Tail risk and dynamic risk

Exhibit 13: Risk of a four-stock portfolio Weekly returns, July 10, 2015–June 26, 2026, from the assigned exercise. The equal-weight portfolio holds 25% each of AAPL, META, NVDA, and TSLA. The cash-replacement portfolio holds 25% each of AAPL, META, NVDA, and zero-return cash. Volatility is annualized using 52 weeks. VaR is the empirical fifth percentile of weekly returns; CVaR is the mean at or below that percentile. For the equal-weight portfolio, a normal distribution with its sample weekly mean (0.75%) and weekly volatility (4.33%) implies a 5% VaR of -6.37% and a 5% CVaR of -8.17%.

Investment	Annual vol.	Weekly 5% VaR	Weekly 5% CVaR
AAPL	27.8%	-5.49%	-8.30%
META	35.7%	-7.23%	-10.64%
NVDA	45.4%	-8.58%	-11.53%
TSLA	58.0%	-11.70%	-14.78%
Equal weight	31.2%	-6.07%	-8.42%
25% cash replacement	21.7%	-4.23%	-6.00%

38. A second analyst removes TSLA from Exhibit 13's equal-weight portfolio and spreads its 25% equally over AAPL, META, and NVDA, leaving no cash. How does that portfolio's annualized volatility compare with the 21.7% of the cash-replacement portfolio?

- **A.** It equals 21.7%, because the same three stocks are held in the same proportions to one another.
- **B.** It equals the average of the three stocks' volatilities, 36.3%, because TSLA no longer diversifies them.
- **C.** It is 4/3 of 21.7%, because every risky weight is scaled up by 4/3 and cash carries no risk.
- **D.** It cannot be ranked against 21.7% without the pairwise correlations among the three remaining stocks, which the exhibit omits.
- **E.** It is below 21.7%, because the 25% now adds diversification across three stocks instead of sitting idle in cash.

39. † **[Select All That Apply]** Which statements about Exhibit 13 are correct?

- ☐ **A.** The equal-weight portfolio's volatility (31.2%) is below the average of the four stocks' volatilities (41.7%); for equal weights this holds whenever the correlations are below one.
- ☐ **B.** The equal-weight portfolio's VaR (-6.07%) is smaller in magnitude than the average of the four stocks' VaRs (-8.25%); VaR is sub-additive, so this holds for any portfolio of the four.
- ☐ **C.** Replacing TSLA with cash lowers volatility by 9.5 percentage points, less than one quarter of TSLA's standalone volatility.
- ☐ **D.** TSLA contributed one quarter of its standalone VaR, about 2.9 percentage points, to the equal-weight portfolio's VaR.
- ☐ **E.** The equal-weight portfolio's CVaR (-8.42%) is smaller in magnitude than the average of the four stocks' CVaRs (-11.31%), but CVaR, like VaR, can violate sub-additivity.

40. For Exhibit 13's equal-weight portfolio, the note gives the 5% VaR and CVaR implied by a normal distribution with the portfolio's sample mean and volatility, -6.37% and -8.17%, against the empirical -6.07% and -8.42%. Which conclusion does the comparison support?

- **A.** The normal model understates risk throughout the lower tail, because weekly stock returns are fat-tailed at every quantile, including the 5% cutoff shown here.
- **B.** At the 5% cutoff the normal model is the more extreme, and beyond it only slightly less so: at this level the normal translation of volatility serves this portfolio adequately.
- **C.** The normal model's more extreme cutoff shows that the sample mean, rather than the shape of the return distribution, drives the differences between the two sets.
- **D.** The sample must be negatively skewed, because its CVaR lies further beyond its VaR than the normal model's CVaR lies beyond its VaR.
- **E.** The close agreement at the 5% cutoff shows the portfolio's weekly returns are close to normal, so the same model can be trusted at the 1% level as well.

Exhibit 14: Backtest of the equal-weight portfolio's 5% VaR The equal-weight portfolio of Exhibit 13, July 10, 2015–June 26, 2026. Each week's 5% normal VaR threshold is $-1.65\sigma_t$, with σ_t estimated from returns through week $t-1$. An exception is a week whose realized return falls below that week's threshold. The final-week columns give each estimator's weekly volatility for the last week of the sample and the threshold it implies. The full-sample empirical 5% VaR of the same portfolio is -6.07%, and its full-sample weekly volatility is 4.3% (31% annualized). Volatility is the sample standard deviation of past returns, using at least two prior observations for the expanding window and the prior 26 weeks for the rolling window; the conditional mean is taken as zero.

Estimator	Weeks	Exceptions	Hit rate	Final-week vol.	Final-week 5% VaR
Expanding window	571	26	4.6%	4.3%	-7.1%
26-week rolling window	547	22	4.0%	3.2%	-5.3%

41. † **[Select All That Apply]** Which statements about the backtest in Exhibit 14 are correct?

- ☐ **A.** The expanding window's hit rate is closer to 5%, so it responds better to changes in volatility over time.
- ☐ **B.** Both dynamic models produced fewer exceptions than the nominal 5% rate.
- ☐ **C.** A hit rate below 5% means the model's threshold was too conservative in every week of the sample.
- ☐ **D.** The rolling model's final-week VaR (-5.3%) is less negative than the expanding model's (-7.1%) because the last 26 weeks were calmer than the sample as a whole.
- ☐ **E.** The hit rates alone do not show whether either model's exceptions arrived in runs, which is a separate failure to test for.

Exhibit 15: Three forecasts for the same week Hypothetical forecasts of the same portfolio, all formed using information available through week $t-1$. Assume zero conditional mean and conditional normal returns, so that for a weekly volatility σ_t the 5% return-threshold VaR is $-1.65\sigma_t$. The realized return in week t is -5.50%.

Estimator	Forecast weekly vol.	5% VaR
Expanding window	2.00%	-3.30%
26-week rolling window	4.00%	-6.60%
EWMA	3.00%	-4.95%

42. † **[Select All That Apply]** Which statements about the forecasts in Exhibit 15 and the realized -5.50% return are correct?

- ☐ **A.** The expanding-window and EWMA forecasts each record an exception this week; the rolling forecast does not.
- ☐ **B.** The rolling model's clean week shows that it was the best-calibrated of the three forecasts.
- ☐ **C.** A single week's exception is consistent with a correctly calibrated 5% model, which should be exceeded about one week in twenty.
- ☐ **D.** The forecasts cannot be compared on the same week, because each estimator was formed from a different information set.
- ☐ **E.** A fair test would re-estimate each forecast including the -5.50% return itself, since that is the latest available information.

43. An EWMA variance update is $\sigma^2_{t+1} = 0.9\sigma^2_t + 0.1r^2_t$, with zero mean assumed. Yesterday's variance estimate was 0.0004 and today's return was -10%. Which statement about the updated estimate is correct?

- **A.** It falls, because the factor 0.9 decays the previous estimate whatever the return.
- **B.** It is unchanged, because the assumed mean of zero makes a -10% return uninformative about variance.
- **C.** It rises by exactly as much as it would after a +10% return, because the return enters through its square.
- **D.** It rises by more than it would after a +10% return, because the update gives losses extra weight relative to gains of the same size.
- **E.** It rises by less than a 26-week rolling estimate would, because the update gives today's return only a 10% weight.

44. In a backtest on weekly returns with fat tails and volatility clustering, a 5% VaR set at -1.65 times a 26-week rolling volatility produced a hit rate closer to 5%, with exceptions spread more evenly in time, than the empirical 5% quantile of all past returns. Which statement explains how the normal-based estimator can beat the distribution-free one here?

- **A.** The rolling window exploits the serial correlation of returns: last week's loss predicts this week's, so its threshold moves ahead of the loss while the all-history quantile cannot.
- **B.** It cannot, unless weekly returns are in fact close to normal; such a result must reflect sampling error in the backtest rather than a property of the estimators.
- **C.** A normal distribution fitted to the most recent 26 weeks is accurate in the tails, which is where a 5% VaR is measured and where an empirical quantile is noisiest.
- **D.** The two estimators produce the same thresholds on average over a long sample, so the ranking is a coincidence of the particular sample and carries no lesson.
- **E.** The rolling volatility responds to the current regime while the all-history quantile pools calm and turbulent periods; the normal shape need not be accurate for that responsiveness to dominate.

45. † **[Select All That Apply]** Use return thresholds, and assume the 5% VaR threshold is negative. Which statements about 5% VaR and CVaR are correct?

- ☐ **A.** CVaR is smaller in magnitude than VaR because it averages over a narrower set of outcomes.
- ☐ **B.** A correctly calibrated 5% VaR model produces no exceptions over a long backtest.
- ☐ **C.** Empirical VaR requires an assumption about the shape of the return distribution, while normal VaR does not.
- ☐ **D.** If weekly returns are serially uncorrelated, the 5% VaR of a two-week return is twice the one-week VaR.
- ☐ **E.** CVaR is the VaR recomputed conditional on the market being in a turbulent regime.

Long-horizon risk

Exhibit 16: A long-horizon model Hypothetical annual log return relative to the risk-free investment: $x_t = \ln(1 + r_{M,t}) - \ln(1 + r_{f,t})$. Assume independent, identically distributed normal x_t, known mean 0.04, and known standard deviation 0.20. Cumulative relative log return over h years is $S_h = \sum_{t=1}^{h} x_t$. Useful normal CDF values: $\Phi(-0.2) = 0.421$, $\Phi(-0.4) = 0.345$, $\Phi(-1) = 0.159$.

Horizon h	Mean of cumulative log return	SD of cumulative log return
1 year	0.04	0.20
4 years	0.16	0.40
25 years	1.00	1.00

46. Under Exhibit 16's assumptions, what is the probability that stocks underperform the risk-free investment over four years?

- **A.** 3.1%
- **B.** 15.9%
- **C.** 34.5%
- **D.** 42.1%
- **E.** 65.5%

47. † **[Select All That Apply]** Comparing one year with 25 years in Exhibit 16, which statements are correct?

- ☐ **A.** The standard deviation of the cumulative relative log return is larger at 25 years.
- ☐ **B.** The standard deviation of the annual-average relative log return is smaller at 25 years.
- ☐ **C.** The probability of underperforming the risk-free investment is smaller at 25 years.
- ☐ **D.** The cumulative relative log return has a smaller standard deviation at 25 years than at one year.
- ☐ **E.** An error in the assumed mean matters less at 25 years, since the average converges to the mean.

Exhibit 17: Evaluating a later return sample Hypothetical Barnstable-style calculation. At the beginning of a 25-year period, an analyst assumes annual stock log returns are independent normal draws with known mean 0.12 and standard deviation 0.20. At the end, the realized average annual stock log return is 0.04. These are stock log returns, not returns relative to bills.

Input	Value
Model mean, fixed before the period	0.12 per year
Model standard deviation	0.20 per year
Observed average over 25 years	0.04 per year

48. Using Exhibit 17, an analyst standardizes the observed 25-year average with the annual standard deviation, obtaining z = (0.04 - 0.12)/0.20 = -0.4, and concludes that the realized average was unremarkable under the model fixed before the period. Which statement is correct?

- **A.** Under the model a 25-year average has standard deviation 0.20/5 = 0.04, so z = -2: an average this low was a two-standard-deviation shortfall, not an unremarkable one.
- **B.** The analyst is right: with independent annual draws, the annual standard deviation describes the dispersion of the 25-year average as well as that of any single year.
- **C.** The analyst should have used the cumulative standard deviation of 1.00 instead, which makes the shortfall even less remarkable than the analyst's z = -0.4 suggests.
- **D.** No standardization is valid here, because the realized volatility of returns over the 25 years is not reported in the exhibit and the model's volatility may have been wrong.
- **E.** Under the model a 25-year average has standard deviation 0.20/25 = 0.008, so z = -10: an average this low was all but impossible under the model.

49. Suppose annual log stock returns relative to bills are independent normal draws with known mean zero and positive constant variance. How does the probability of stocks underperforming bills compare at one year and 25 years?

- **A.** It is lower at 25 years because the annual average return is more concentrated around zero.
- **B.** It is higher at 25 years because the cumulative log-return variance is 25 times larger.
- **C.** It cannot be compared without the numerical value of the positive variance and the horizon.
- **D.** It is 50% at both horizons because the cumulative distribution stays centered at zero.
- **E.** It is lower at 25 years because the 25-year Sharpe ratio is five times the one-year ratio.

50. † **[Select All That Apply]** A Barnstable-style calculation gives a 2% probability that stocks underperform bills over 30 years. The model assumes independent, identically distributed normal annual log returns relative to bills, with positive mean and positive variance, and treats the sample mean and volatility as known inputs. Which statements are correct?

- ☐ **A.** The 2% reflects the sampling error in the estimated mean and volatility as well as the return risk.
- ☐ **B.** The 2% is the probability that the 30-year cumulative stock return itself is negative.
- ☐ **C.** The 2% is conditional on the inputs; a lower true mean or a higher true volatility would raise it.
- ☐ **D.** The 2% means the shortfall relative to bills, when it does occur, is small.
- ☐ **E.** The 2% would be unchanged if annual returns were positively autocorrelated rather than independent.

51. The Barnstable-style argument that stocks are safe relative to bills over long horizons rests on more than the probability calculation. Which practical condition did the lecture stress as necessary before an investor can rely on it?

- **A.** Annual returns need to be normally distributed over the whole horizon, since the probability calculation relies on the normal distribution.
- **B.** The volatility estimate must come from the same historical sample as the mean estimate, so that the two inputs are consistent.
- **C.** The investor must be able to keep the capital committed through interim losses; the calculation says nothing about the path before the horizon ends.
- **D.** The investor must rebalance to a constant stock weight every year, because that is what makes returns independent across years.
- **E.** The risk-free rate must stay constant over the horizon, so that the return relative to bills has a known mean and variance.

52. Investment X has annual arithmetic mean 8% and volatility 10%; Y has mean 10% and volatility 30%. Using $E[\log(1+r)] \approx E[r] - \sigma^2/2$ with returns in decimals gives approximate mean log returns of 7.5% for X and 5.5% for Y. Why does Y, with the higher arithmetic mean, have the lower mean log return?

- **A.** Y's variance drag exceeds X's by four points, more than Y's two-point advantage in arithmetic mean.
- **B.** Y's volatility is three times X's, so its mean log return is roughly one third of X's.
- **C.** The approximation subtracts half the volatility from the arithmetic mean, and Y's volatility is the larger.
- **D.** Y's lower figure arises only because the approximation ignores skewness, which would restore its advantage.
- **E.** The log correction removes sampling error in the arithmetic mean, and that error is larger for Y.

CAPM and DFA

Exhibit 18: CAPM regressions for size–value portfolios Monthly data, January 1981–August 2025, from the assigned DFA data file. Portfolio total returns have been converted to excess returns using RF. Separate OLS regressions on Mkt-RF include an intercept. The annualized sample market excess mean is 8.50%. LoBM denotes low book-to-market; HiBM denotes high book-to-market. Means and alphas are annualized; betas and R^2 are not.

Portfolio	Mean excess	Beta	Alpha	R^2
Small LoBM	1.17%	1.358	-10.37%	0.601
Small HiBM	12.73%	0.994	4.29%	0.548
Big LoBM	9.49%	0.995	1.03%	0.894

53. In Exhibit 18, which explanation accounts for the large negative alpha of Small LoBM?

- **A.** Its beta is negative, so the CAPM predicts a negative excess return for it.
- **B.** Its beta exceeds one, and the CAPM assigns a negative alpha to any portfolio with beta above one.
- **C.** Its 1.17% mean is far below the roughly 11.5% mean implied by its market exposure.
- **D.** The annualized market return should be subtracted once from every portfolio, regardless of beta.
- **E.** Its high volatility creates a variance drag on its mean that the CAPM-implied mean leaves out.

54. † **[Select All That Apply]** Which conclusions from Exhibit 18 are correct?

- ☐ **A.** Big LoBM's R-squared of 0.894 makes its population alpha zero to within rounding.
- ☐ **B.** Small HiBM and Big LoBM have almost the same estimated beta but sample mean excess returns 3.2 percentage points apart.
- ☐ **C.** Small LoBM's negative alpha means its average excess return over the sample was negative.
- ☐ **D.** The table reports estimated pricing errors; sampling uncertainty is needed to assess their statistical significance.
- ☐ **E.** The two LoBM alphas have opposite signs, so low book-to-market alone does not set the sign of the pricing error.

Exhibit 19: The CAPM cross-sectional test on the 25 portfolios Results from the same data and sample as Exhibit 18, January 1981–August 2025 (536 months), for all 25 size–value portfolios; Exhibit 18 shows three of the 25 time-series regressions. The cross-sectional regression explains the 25 annualized sample mean excess returns with the 25 estimated betas: $\bar{r}_i^e = \eta + \lambda\widehat{\beta}_i + v_i$. The annualized sample market excess return is 8.5%. The 25 time-series R^2 values range from 0.55 to 0.89.

Diagnostic	Estimate
Cross-sectional intercept η, annualized	20.6%
Cross-sectional slope λ, annualized	-10.6%
Cross-sectional R^2	0.31
Range of the 25 estimated betas	0.88 to 1.36
Mean absolute time-series alpha, annualized	2.07%
Signed mean of the 25 time-series alphas, annualized	0.3%
Joint test of the 25 alphas, H	125.9
Degrees of freedom; p-value	25; below 0.001

55. Suppose the CAPM held exactly in population and were estimated without error, with the population market premium equal to the 8.5% sample mean. What would the cross-sectional regression in Exhibit 19 show?

- **A.** $\eta = 0$, $\lambda = 8.5\%$, and R^2 equal to the average time-series R^2.
- **B.** $\eta = 8.5\%$, $\lambda = 0$, and $R^2 = 1$.
- **C.** $\eta = 0$, $\lambda = 1$, and $R^2 = 1$.
- **D.** $\eta = 0$, $\lambda = 8.5\%$, and $R^2 = 1$.
- **E.** η equal to the risk-free rate, $\lambda = 8.5\%$, and $R^2 = 1$.

56. † **[Select All That Apply]** Which statements about Exhibit 19 are correct?

☐ **A.** Across the 25 portfolios, higher market betas went with lower average excess returns.
☐ **B.** The signed mean alpha of 0.3% per year means the CAPM pricing errors are economically small.
☐ **C.** The joint-test p-value means the market return explains little of the portfolios' month-to-month variation.
☐ **D.** The time-series alphas and the cross-sectional fit point the same way: market beta does not explain these mean returns as the CAPM requires.
☐ **E.** The intercept of 20.6% is the average excess return earned by the lowest-beta portfolios in the sample.

57. † **[Select All That Apply]** Assume the population CAPM holds and the market expected excess return is positive. Two funds have the same positive market beta, but Fund X has greater idiosyncratic variance. Which statements are correct?

☐ **A.** X earns a higher expected excess return to compensate for the extra idiosyncratic variance.
☐ **B.** The two funds have the same expected excess return.
☐ **C.** The two funds have equal Sharpe ratios because their market betas agree.
☐ **D.** X has higher total variance when both residuals are orthogonal to the same market factor.
☐ **E.** X's excess return has the lower correlation with the market excess return.

Exhibit 20: DFA factor statistics by subsample Monthly factor returns from the assigned DFA workbook. Mkt-RF, SMB, and HML are already excess or long-short returns. Means and volatilities are annualized; the Sharpe ratio is mean divided by volatility. In 1981–2001 the correlation between Mkt-RF and HML was -0.53.

Factor	1926–1980: mean / vol / Sharpe	1981–2001: mean / vol / Sharpe	2002–Aug 2025: mean / vol / Sharpe
Mkt-RF	8.1% / 20.5% / 0.39	7.8% / 15.7% / 0.50	9.1% / 15.4% / 0.59
SMB	3.4% / 11.4% / 0.30	-0.2% / 11.7% / -0.02	0.8% / 8.8% / 0.09
HML	5.0% / 13.4% / 0.37	6.5% / 11.0% / 0.59	0.1% / 10.6% / 0.01

58. † **[Select All That Apply]** Which conclusions does Exhibit 20 support?

- ☐ **A.** Each of the three factors has a positive sample premium in each subsample.
- ☐ **B.** The size premium is smaller after 1980 than before 1980.
- ☐ **C.** Since 2002 the value premium has been close to zero, while the market premium has been the largest of the three in every subsample shown.
- ☐ **D.** Because HML's volatility fell from 13.4% to 11.0% between the first two subsamples, its Sharpe ratio fell.
- ☐ **E.** SMB's Sharpe ratio of -0.02 in 1981–2001 shows that small stocks were riskier than large stocks in that subsample.

59. An investor holds the market over 1981–2001 and adds a sufficiently small positive exposure to the zero-cost HML long-short factor, keeping the market position fixed. Treat the printed 1981–2001 moments in Exhibit 20 as expected inputs. Which statement is correct?

- **A.** Expected excess return rises but variance rises too, because any added position adds risk.
- **B.** The addition cannot improve the portfolio because the market's Sharpe ratio was the higher one.
- **C.** The effect cannot be assessed without HML's beta on SMB and the SMB premium.
- **D.** Expected excess return rises and variance initially falls, because HML's premium was positive and its market correlation negative.
- **E.** Expected excess return is unchanged because HML is zero-cost, while variance falls because of the negative correlation.

60. † **[Select All That Apply]** Suppose the CAPM held exactly in population with a positive market expected excess return, every portfolio has a nonzero beta, and every residual volatility is positive. For the 25 time-series regressions of portfolio excess returns on the market excess return, which population statements would be true?

- ☐ **A.** Every alpha equals zero.
- ☐ **B.** Every Treynor ratio equals the market's expected excess return.
- ☐ **C.** Every information ratio equals zero.
- ☐ **D.** Portfolios with higher betas have higher Sharpe ratios.
- ☐ **E.** No portfolio's Sharpe ratio exceeds the market's.

61. Assume the CAPM holds, the risk-free rate is 3%, and the market's expected excess return is 6%. An asset with market beta -0.5 has an expected total return of:

- **A.** -3%
- **B.** 0%
- **C.** 1.5%
- **D.** 3%
- **E.** 6%

62. † **[Select All That Apply]** Which statements correctly distinguish a joint alpha test from descriptive alpha summaries?

☐ **A.** For given alphas, residual covariances, and market Sharpe ratio, the joint test statistic grows in proportion to the sample length.

☐ **B.** An MAE on its own determines significance without sample size or uncertainty information.

☐ **C.** A joint test can account for dependence among estimated alphas through their sampling covariance.

☐ **D.** One portfolio with a significant individual alpha t-statistic makes the joint test reject.

☐ **E.** A joint rejection shows which of the 25 portfolios carry the nonzero alphas.