#### AIM 04 Performance measurement

AIM 04.3 Multiple risk factor performance

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## Multiple risk factors

#### □ Context:

- Performance evaluation notes have discussed how to:
  - □ Analyze tracking error.
  - □ Assess single-factor risk-adjusted performance.
  - ☐ Isolate managerial skill using portable alpha strategies.
- Now turn to assessing performance of funds with multiple market price risk factor exposures.
  - □ Some risks may be known (e.g., convertible bond funds).
  - □ Some risks may be unknown (e.g., hedge funds).

## Multiple risk factors

- □ <u>Purpose</u>:
  - Develop framework for:
    - Assessing performance when measurement for multiple price risk factors.
    - Hedging unwanted market risk exposures.
    - ☐ Transporting investor skill to different asset categories.

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## Steps in risk assessment process

- ☐ Try to identify all <u>tradable</u> market risk factors that may affect fund returns.
- □ Regress excess fund returns on excess returns of price risk factors.
  - Excess returns can be based on:
    - □ ETP return
    - Futures return
- □ Eliminate insignificant factors and re-estimate.
- □ Intercept is risk-adjusted performance.

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#### Return to BOND

- □ Recall BOND analysis (BOND analysis II.xlsx).
  - Bought PIMCO's BOND ETF.
  - Short sold Vanguard's BND to:
    - □ Hedge long-term interest rate risk, and
    - □ Isolate manager's alpha.
  - Took cash from short sale and bought VTI.
    - Overlaid managerial skill from PIMCO's BOND fund onto stock market (where alpha is hard to find).
  - Problem arose.
    - Alpha changed.
    - □ Beta was not equal to one.

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#### Return to BOND

□ Bought VTI with investment funds (cash generated from short sale) while holding BOND alpha.

Regression on VTI					
	Alpha+VTI				
n	2,701				
$\alpha$	0.000045				
$s(\alpha)$	0.000028				
β	1.010690				
$s(\beta)$	0.002496				
R-squared	0.983801				
Adj. R-squared	0.983795				
Std error of estimate	0.001453				

Why isn't alpha equal to 0.000049 and beta equal to one?

<u>Answer</u>: Because BOND also has stock market risk exposure.

#### Return to BOND

- □ Regress excess return of BOND on excess returns of BND and VTI.
  - BOND has two-factor risk exposures.

$$XR_{BOND,t} = \alpha_{BOND} + \beta_{BND,t}XR_{BND,t} + \beta_{VTI}XR_{VTI,t} + \varepsilon_{BOND,t}$$

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## Return to BOND

□ BOND has exposures to long-term interest rate risk and US stock market risk.

Excess return	regression o	f BOND on	BND and	VTI	
Multiple R	0.8644				
R Square	0.7471				s significant exposures
Adjusted R Square	0.7469		to	bonds a	and stocks.
Standard Error	0.0015				
Observations	2,701		A	bnormal	performance is 0.000045.
	Coeff	StErr	t Stat	P-value	
Intercept	0.000045	0.000028	1.59	0.1110	•
BND	0.806364	0.009099	88.62	0.0000	
VTI	0.010748	0.002504	4 29	0.0000	

#### Return to BOND

□ Can hedge exposures by short selling 0.806364 BND and 0.010748 VTI.

Regression of alpha porfolio on excess returns of BND and VTI						
Multiple R	0.0000		41.1			
R Square	0.0000	Alpha portfolio has no market risk,				
Adjusted R Square	-0.0007	no investment, and outperformance.				
Standard Error	0.0015					
Observations	2,701					
	Coeff	StErr	t Stat	P-value		
Intercept	0.000045	0.000028	1.59	0.1110		
BND	0.000000	0.009099	0.00	1.0000		
VTI	0.000000	0.002504	0.00	1.0000		

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# Return to BOND

- □ Want stock market beta of one.
  - Short sell 0.806364 BND and buy (1 0.010748) VTI.

Regression of	of alpha porfo	lio + VTI on	VTI excess r	eturn		
Multiple R	0.9917		3.6.4		( PONTO	
R Square	0.9835				a from BOND,	
Adjusted R Square	0.9835		and o	verlaid it o	n stock market risk.	
Standard Error	0.0015					
Observations	2,701					
	Coeff	StErr	t Stat	P-value		
Intercept	0.000045	0.000028	1.59	0.1109	-	
VTI	1.000000	0.002496	400.59	0.0000		
	Viola, portable alpha!					

#### Review steps

- ☐ Try to identify all <u>tradable</u> market risk factors that may affect fund returns.
- □ Regress excess fund returns on excess returns of price risk factors.
  - Excess returns can be based on:
    - □ ETP return
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- □ Intercept is risk-adjusted performance.

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## Two more applications

- □ Apply technique in two additional applications.
  - Alpha Beta Fund
    - □ Uses convertible bond trading strategy.
    - □ Hedge stock market exposure using futures.
  - Gamma Fund
    - Also uses convertible bond trading strategy.
    - Create bond market risk using futures.
    - Overlay stock market alpha on bond performance.

## Alpha Beta Fund

- ☐ Hedge fund manager claims to be able to identify under- and over-priced convertible bonds.
  - Provides historical record showing abnormal riskadjusted performance when benchmarked against the S&P 500.
    - □ Historical data for hedge funds in typically monthly.
- □ Support file: Alpha Beta Fund.xlsx

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## Alpha Beta Fund

□ Take record and perform due diligence.

ALPHA BETA CONVERTIBLE BOND FUND						
			Excess	Index	Index	
- (	Fund	Money	fund	futures	futures	
Mont	n value	market	return	price	return	
0	122,413,208			801.67		
1	117,241,194	0.001054	-0.044223	755.82	-0.058893	
2	110,732,395	0.002881	-0.059998	675.54	-0.112294	
3	101,269,649	0.003038	-0.092368	676.54	0.001482	
4	101,950,545	0.002871	0.003830	632.49	-0.067335	
5	96,205,445	0.001979	-0.059981	585.56	-0.077088	
6	99,833,854	0.002115	0.034906	610.15	0.041133	
7	97,448,951	0.002049	-0.026227	617.96	0.012723	
59	158,983,305	0.002891	-0.018803	744.87	-0.040201	
60	169,143,914	0.002823	0.059128	787.50	0.055649	
١ (		,				

60 months of audited fund values provided by manager.

Money market is return on cash equivalents.

Futures price (returns) on stock index (e.g., S&P 500).

# Alpha Beta Fund

□ Take record and perform due diligence.

ALPHA BETA CONVERTIBLE BOND FUND						
			Excess	Index	Index	
	Fund	Money	fund	futures	futures	
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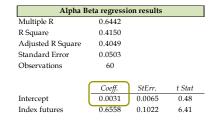
Regress 60 months of excess returns of fund *P* on excess returns of stock index price risk factor.

Using futures:  $R_{P,t} - r_t = \alpha + \beta_{SI} R_{SIF,t} + \varepsilon_t$  or Using ETP:  $R_{P,t} - r_t = \alpha + \beta_{SI} (R_{SI,t} - r_t) + \varepsilon_t$ 

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# Alpha Beta Fund

□ Excess return regression results show:



Manager's claim is true. On a risk-adjusted basis, fund outperformed S&P 500 by 31 basis points per month or (0.31% x 12 =) 3.72% annually.

## Alpha Beta Fund

- □ Before concluding manager has great investment skills, **think**.
  - Convertible bonds have two market risk exposures.
    - □ Equity risk exposure
    - □ Long-term interest rate risk exposure
  - His performance regression specification is wrong.
    - □ Has missing variables problem.

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## Alpha Beta Fund

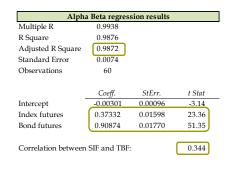
□ Correct regression specification also requires longterm interest rate risk factor:

$$R_{P,t} - r_t = \alpha + \beta_{SI} R_{SIF,t} + \beta_{TB} R_{TBF,t} + \varepsilon_t$$

Use T-bond futures returns to proxy for long-term interest rate exposure.



□ Collect historical price data for bond futures.



Regression has great explanatory power.

Fund returns clearly depend on both stock and bond price risk factors.

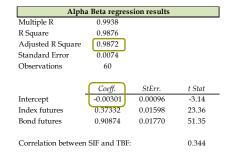
Stock index return coefficient fell because it previously also proxied for bond price movements.

- Called missing variable bias.

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## Alpha Beta Fund

□ Collect historical price data for bond futures.



Adjusting for market price risks properly, manager underperforms by 30 basis points a month or 3.6% annually.

Unsavory character tried to dupe us!

#### Avoid mistake by:

- Using common sense.
- Identifying complete list of market factors.
- Applying knowledge of statistics.

#### Setting futures hedge

- □ To demonstrate use of futures to manage risk, hedge stock market and interest rate risk exposures of Alpha Beta using futures.
  - Will have negative abnormal performance.

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## Setting futures hedge

- □ Sell S&P 500 e-mini futures.
  - Index futures denomination is 50.
  - Number of contracts to sell is

$$n_{SIF} = \beta_{SI} \left( \frac{\text{Fund value}}{\text{Contract denomination}_{SI} \times \text{Futures price}_{SI}} \right)$$

- □ Sell T-bond futures.
  - Bond futures denomination is 1,000.
  - Number of contracts to sell is

$$n_{TBF} = \beta_{TB} \left( \frac{\text{Fund value}}{\text{Contract denomination}_{TB} \times \text{Futures price}_{TB}} \right)$$

# Setting futures hedge

□ Solving.

$$n_{SIF} = 0.37332 \left( \frac{169,143,914}{50 \times 787.50} \right) = 1,503.68$$

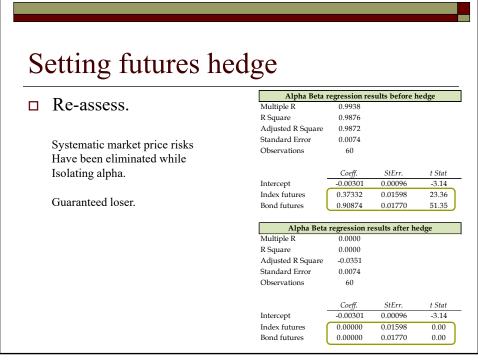
$$n_{TBF} = 0.90874 \left( \frac{169,143,914}{1,000 \times 146.39} \right) = 1,050.00$$

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## Setting futures hedge

- □ To isolate *portable alpha* for this fund, hedge stock market and interest rate risk exposures.
  - Portable alpha return is

$$PA_{t} = R_{P,t} - r_{t} - \hat{\beta}_{SI} R_{SIF,t} - \hat{\beta}_{TB} R_{TBF,t}$$
$$= R_{P,t} - r_{t} - 0.37332 R_{SIF,t} - 0.90874 R_{TBF,t}$$



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#### Gamma Fund

- □ Competing manager also claims to be able to identify under- and over-priced convertible bonds.
  - Provides historical record showing abnormal riskadjusted performance when benchmarked against the S&P 500.
- □ Support file: Gamma Fund.xlsx



- □ Will not be duped this time.
  - Immediately assess performance using S&P 500 futures and T-bond futures returns.

$$R_{P,t} - r_t = \alpha + \beta_{SI} R_{SIF,t} + \beta_{TB} R_{TBF,t} + \varepsilon_t$$

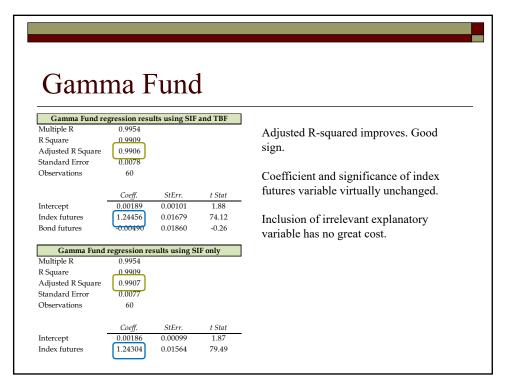
0.9954		
0.7734		
0.9909		
0.9906		
0.0078		
60		
Coeff.	StErr.	t Stat
0.00189	0.00101	1.88
1.24456	0.01679	74.12
0.00490	0.01860	-0.26
	0.9909 0.9906 0.0078 60 Coeff. 0.00189	0.9909 0.9906 0.0078 60 Coeff. StErr. 0.00189 0.00101 1.24456 0.01679

Strong explanatory power.

Only index futures has significant coefficient. Bond futures is irrelevant.

Remove bond futures return variable, and re-run regression.

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#### Gamma Fund

- □ Know Gamma manager has managerial skill.
  - Alpha is positive.
- □ Problem is you believe:
  - Stock market investors are nervous and want to eliminate their market exposure while retaining Gamma Fund's alpha.
  - Replace with long-term bond exposure 1.5 times higher than T-bonds.

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#### Gamma Fund

- □ You want to make *tactical decision*.
  - Retain alpha of Gamma Fund.
  - Eliminate stock market exposure.
  - Take on long-term interest rate exposure 1.5 times higher than bond market.
- ☐ This tactical decision is also called *market timing decision*.

#### Gamma Fund

- ☐ Since you want long-term interest exposure, return to two price risk-factor regression.
- □ Excess return of stock index hedged portfolio is

$$\begin{split} XR_{TB,t} &= R_{P,t} - r_t - \left(\hat{\beta}_{SI}R_{SIF,t} + \hat{\beta}_{TBF}R_{TBF,t}\right) + 1.5R_{TBF,t} \\ &= R_{P,t} - r_t - \left(1.24304R_{SIF,t} + \left(-0.00490 - 1.5\right)R_{TBF,t}\right) \end{split}$$

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#### Gamma Fund

□ Re-assess.

ılts hedging	SIF and leveri	ing TBF
0.9962		
0.9923		
0.9921		
0.0078		
60		
Coeff.	StErr.	t Stat
0.00189	0.00101	1.88
0.00000	0.01679	0.00
1.50000	0.01860	80.66
	0.9962 0.9923 0.9921 0.0078 60 Coeff. 0.00189 0.00000	0.9923 0.9921 0.0078 60 Coeff: StErr. 0.00189 0.00101 0.00000 0.01679

Hedged stock market exposure and levered T-bond exposure, all while maintaining manager's alpha.

#### Lesson summary

- □ Performance measurement must account for all systematic market price risk exposures, e.g., equity, interest rate, volatility, commodity, etc.
  - Failure to do so will misstate performance due to missing variable bias.
  - Including irrelevant risk factors is non-issue.
  - Price risk factors must be <u>tradable</u> and <u>low cost</u>.
  - Generate excess returns for price risk factors using:
    - □ ETPs
    - Futures