Module 14.1

Portfolio Issues
Portfolio Risk Management

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Overview

- Provide several perspectives on portfolio risk
- Examine nine stocks and nine sector ETFs
- Contrast with SPY, passive index ETF
- Illustrate marginal analysis of risk
- Introduce diversification benefits
  - Volatility benefits
  - Return due to diversification

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Perspectives on Portfolio Risk

- Individual stocks and sector ETFs
- Individual versus portfolio
  - Total return
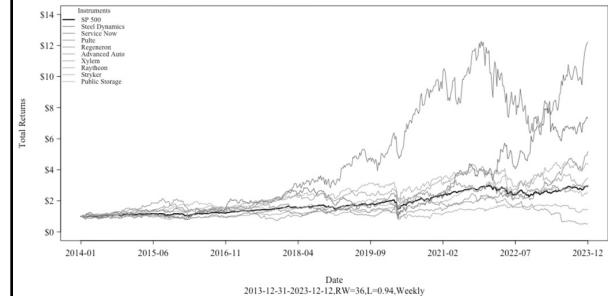 - Standard deviation
  - Beta
  - Volatility benefit

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Figure 14.1.1. Total Return Illustration with Nine Individual Stocks

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Figure 14.1.2. Total Return Illustration with Nine Sector ETFs
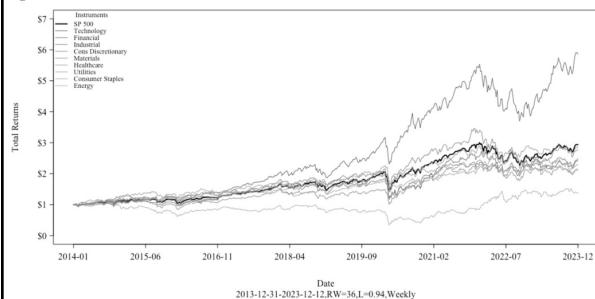
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Figure 14.1.3. Rolling Standard Deviation Illustration with Nine Individual Stocks

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Figure 14.1.4. Rolling Standard Deviation Illustration with Nine Sector ETFs

Figure 14.1.5. Rolling Beta Illustration with Nine Individual Stocks

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Figure 14.1.6. Rolling Beta Illustration with Nine Sector ETFs

Figure 14.1.7. Rolling Volatility Benefit Illustration with Average of Nine Individual Stocks
(SP 500, Steel Dynamics...)

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Figure 14.1.8. Rolling Volatility Benefit Illustration with Average of Nine Sector ETFs
(SP 500, Technology...)
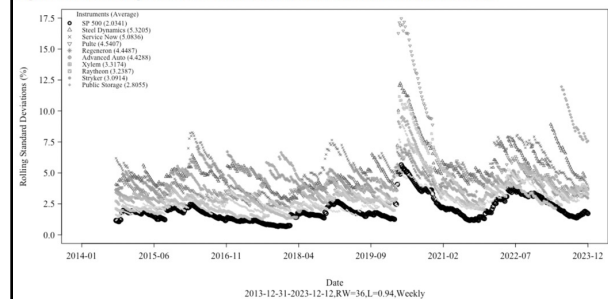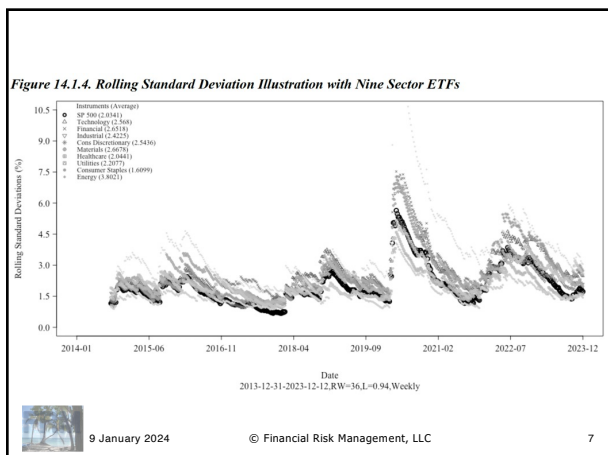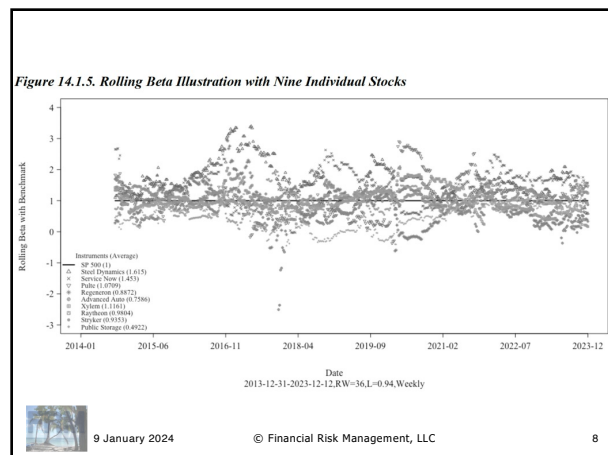
Marginal Influence of Additional Instruments

- Range from one to nine instruments
- Individual stocks and sector ETFs
- Individual versus portfolio
  - Total return
  - Standard deviation
  - Beta
  - Volatility benefit
- Slide show illustrations

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Figure 14.1.9. Marginal Influence on Total Return with Individual Stocks
Panel A: One Stock with SPY

Note: Steel Dynamics (STLD).

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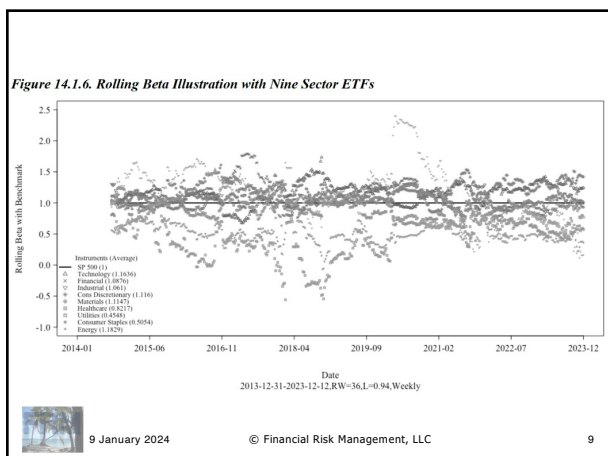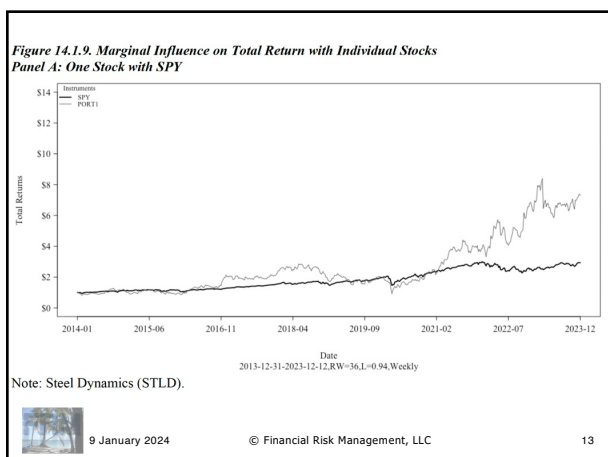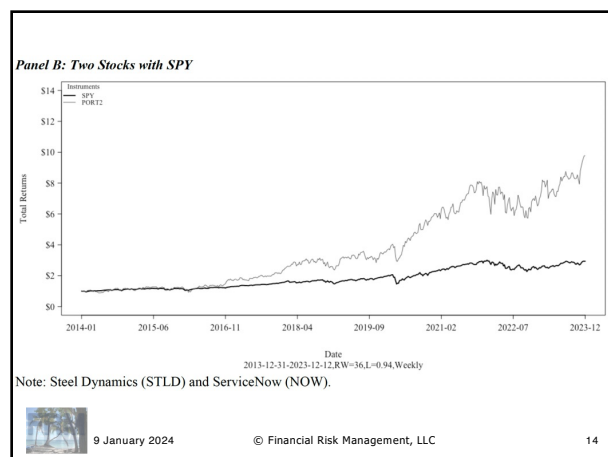
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Panel B: Two Stocks with SPY

Note: Steel Dynamics (STLD) and ServiceNow (NOW).

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Panel C: Three Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), and Pulte Group (PHM).

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Panel D: Four Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), and Regeneron (REGN).

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Panel E: Five Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), and Advance Auto Parts (AAP).

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Panel F: Six Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), and Xylem (XYL).

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Panel G: Seven Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), and Raytheon (RTX).

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Panel H: Eight Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), and Stryker (SYK).

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Panel I: Nine Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), Stryker (SYK), Public Storage (PSA).

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Figure 14.1.10. Marginal Influence on Total Return Illustration with Sector ETFs
Panel A: One Sector ETF with SPY

Note: Technology (XLK).

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Panel B: Two Sector ETFs with SPY

Note: Technology (XLK) and Finance (XLF).

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Panel C: Three Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), and Industrial (XLI).

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Panel D: Four Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), and Consumer Discretionary (XLY).

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Panel E: Five Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), and Materials (XLB).

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Panel F: Six Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), and Healthcare (XLV).

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Panel G: Seven Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), and Utilities (XLU).

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Panel H: Eight Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), and Consumer Staples (XLP).

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Panel I: Nine Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), Consumer Staples (XLP), and Energy (XLE).

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Figure 14.1.11. Marginal Influence on Rolling Standard Deviation Illustration with Individual Stocks
Panel A: One Stock with SPY

Note: Steel Dynamics (STLD).

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Panel B: Two Stocks with SPY

Note: Steel Dynamics (STLD) and ServiceNow (NOW).

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Panel C: Three Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), and Pulte Group (PHM).

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Panel D: Four Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), and Regeneron (REGN).

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Panel E: Five Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), and Advance Auto Parts (AAP).

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Panel F: Six Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), and Xylem (XYL).

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Panel G: Seven Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), and Raytheon (RTX).

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Panel H: Eight Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), and Stryker (SYK).

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Panel I: Nine Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), Stryker (SYK), Public Storage (PSA).

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Figure 14.1.12. Marginal Influence on Rolling Standard Deviation Illustration with Sector ETFs
Panel A: One Sector ETF with SPY

Note: Technology (XLK).

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Panel B: Two Sector ETFs with SPY

Note: Technology (XLK) and Finance (XLF).

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Panel C: Three Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), and Industrial (XLI).

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Panel D: Four Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), and Consumer Discretionary (XLY).

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Panel E: Five Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), and Materials (XLB).

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Panel F: Six Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), and Healthcare (XLV).

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Panel G: Seven Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), and Utilities (XLU).

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Panel H: Eight Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), and Consumer Staples (XLP).

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Panel I: Nine Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), Consumer Staples (XLP), and Energy (XLE).

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Figure 14.1.13. Individual Stock Average Rolling Portfolio Standard Deviations

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Figure 14.1.14. Individual Stock Percent of SPY Average Rolling Portfolio Standard Deviations

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Figure 14.1.15. Sector ETFs Average Rolling Portfolio Standard Deviations

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Figure 14.1.16. Sector ETFs Percent of SPY Average Rolling Portfolio Standard Deviations

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Figure 14.1.17. Marginal Influence on Rolling Beta Illustration with Individual Stocks
Panel A: One Stock with SPY

Note: Steel Dynamics (STLD).

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Panel B: Two Stocks with SPY

Note: Steel Dynamics (STLD) and ServiceNow (NOW).

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Panel C: Three Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), and Pulte Group (PHM).

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Panel D: Four Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), and Regeneron (REGN).

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Panel E: Five Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), and Advance Auto Parts (AAP).

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Panel F: Six Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), and Xylem (XYL).

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Panel G: Seven Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), and Raytheon (RTX).

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Panel H: Eight Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), and Stryker (SYK).

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Panel I: Nine Stocks with SPY

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), Stryker (SYK), Public Storage (PSA).

Figure 14.1.18. Marginal Influence on Rolling Beta Illustration with Sector ETFs
Panel A: One Sector ETF with SPY

Note: Technology (XLK).

Panel B: Two Sector ETFs with SPY

Note: Technology (XLK) and Finance (XLF).

Panel C: Three Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), and Industrial (XLI).

Panel D: Four Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), and Consumer Discretionary (XLY).

Panel E: Five Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), and Materials (XLB).

Panel F: Six Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), and Healthcare (XLV).

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Panel G: Seven Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), and Utilities (XLU).

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Panel H: Eight Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), and Consumer Staples (XLP).

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Panel I: Nine Sector ETFs with SPY

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), Consumer Staples (XLP), and Energy (XLE).

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Diversification Benefit

- Measures
  - Volatility Benefit (VB)
  - Return Due to Diversification (RDD)
- Following figures present the rolling volatility benefit
  - Individual stocks and sector ETFs
  - Time series unstable

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Simple Example

TABLE 14.1.1. Basic Data for Illustration of Concepts

	Asset Class 1	Asset Class 2	Portfolio
Portfolio Weights (%)	37.50%	62.50%	100.00%
Period 1	40%	−10%	8.75%
Period 2	−10%	20%	8.75%
Average Returns (%)	15.00%	5.00%	8.75%
Standard Deviations (%)	25.00%	15.00%	0.00%

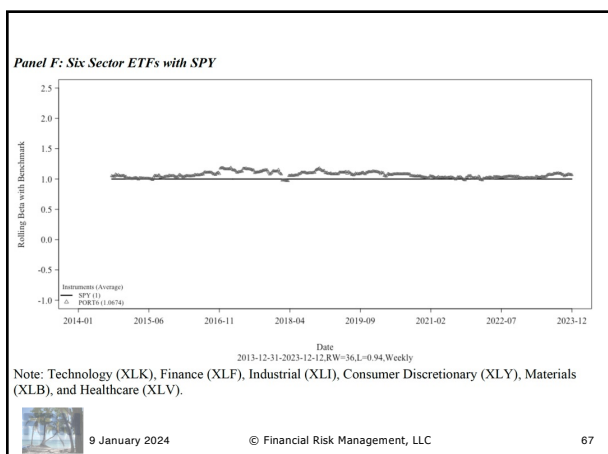Benefit in terms of volatility (percentage gain over weighted average standard deviation):

$$VB_{\pi,t} = 1 - \frac{\sigma_{\pi,t}}{\sum_{i=1}^{N} w_{i,t}\sigma_{i,t}} = 1 - \frac{0}{0,.375(0.25)+0.6250(0.15)} = 1.0$$

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Figure 14.1.19. Marginal Influence on Rolling Volatility Benefit Illustration with Individual Stocks
Panel A: One Stock with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT1)

Note: Steel Dynamics (STLD).

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Panel B: Two Stocks with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT2)

Note: Steel Dynamics (STLD) and ServiceNow (NOW).

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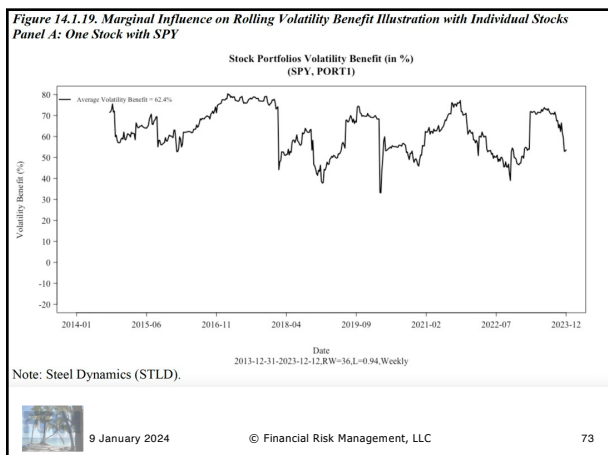**Panel C: Three Stocks with SPY**

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT3)

Note: Steel Dynamics (STLD), Service Now (NOW), and Pulte Group (PHM).

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Panel D: Four Stocks with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT4)

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), and Regeneron (REGN).

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Panel E: Five Stocks with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT5)

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), and Advance Auto Parts (AAP).

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Panel F: Six Stocks with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT6)

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), and Xylem (XYL).

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Panel G: Seven Stocks with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT7)

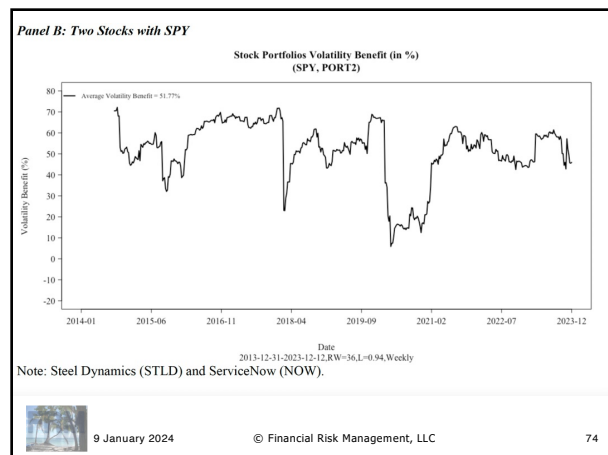Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), and Raytheon (RTX).

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Panel H: Eight Stocks with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT8)

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), and Stryker (SYK).

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Panel I: Nine Stocks with SPY

Stock Portfolios Volatility Benefit (in %)
(SPY, PORT9)

Note: Steel Dynamics (STLD), Service Now (NOW), Pulte Group (PHM), Regeneron (REGN), Advance Auto Parts (AAP), Xylem (XYL), Raytheon (RTX), Stryker (SYK), Public Storage (PSA).

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Figure 14.1.20. Marginal Influence on Rolling Volatility Benefit Illustration with Sector ETFs
Panel A: One Sector ETF with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT1)

Note: Technology (XLK).

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Panel B: Two Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT2)

Note: Technology (XLK) and Finance (XLF).

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Panel C: Three Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT3)

Note: Technology (XLK), Finance (XLF), and Industrial (XLI).

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Panel D: Four Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT4)

Note: Technology (XLK), Finance (XLF), Industrial (XLI), and Consumer Discretionary (XLY).

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Panel E: Five Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT5)

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), and Materials (XLB).

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Panel F: Six Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT6)

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), and Healthcare (XLV).

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Panel G: Seven Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT7)

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), and Utilities (XLU).

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Panel H: Eight Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT8)

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), and Consumer Staples (XLP).

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Panel I: Nine Sector ETFs with SPY

Sector ETF Portfolios Volatility Benefit (in %)
(SPY, PORT9)

Note: Technology (XLK), Finance (XLF), Industrial (XLI), Consumer Discretionary (XLY), Materials (XLB), Healthcare (XLV), Utilities (XLU), Consumer Staples (XLP), and Energy (XLE).

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Figure 14.1.21. Individual Stock Average Rolling Portfolio Volatility Benefit

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Figure 14.1.22. Individual Stock Percent of SPY Average Rolling Portfolio Volatility Benefit

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Figure 14.1.23. Sector ETFs Average Rolling Portfolio Volatility Benefit

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Figure 14.1.24. Sector ETFs Percent of SPY Average Rolling Portfolio Volatility Benefit

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Volatility Benefit Summary

- Diversification Benefit can be expressed in terms of VB (percentage gain over weighted average standard deviation)
- Ranges between 0% and 100%
- Normal market VB tends to be significantly higher than stressed markets
- VB is quite volatile over time

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Return Due to Diversification

- Diversification Benefit can be expressed in terms of Return Due to Diversification (RDD)
- Based on difference between arithmetic and geometric returns
- Applies Taylor Series approximation
- Decomposition of RDD to Return Contribution (RC) of each instrument
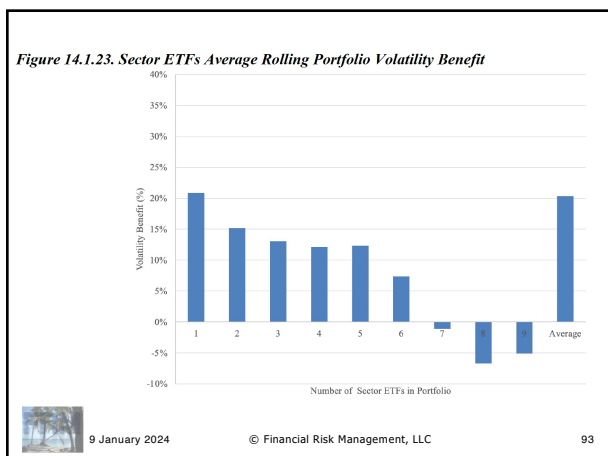
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Simple Example - Expanded

TABLE 14.1.2. Expanded Data for Illustration of Concepts

Asset Class	1			2			Portfolio		
	Value	r_d	r_c	Value	r_d	r_c	Value	r_d	r_c
Weights (%)	37.50			62.50			100		
Period 0	$100			$100			$100		
Period 1	$140	40%	33.6472%	$90	−10%	−10.5361%	$108.75	8.75%	8.388%
Period 2	$126	−10%	−10.5361%	108	20%	18.2322%	$118.2656	8.75%	8.388%
Average (%)		15%	11.5555%		5%	3.84805%		8.75%	8.388%
St. Dev. (%)		25%			15%			0%	0%

Arithmetic Average: $AR_1 = \frac{1}{n}\sum_{i=1}^{n} R_{1,i} = \frac{1}{2}\left[0.4 + (-0.1)\right] = 0.15$ and (14.1.2)

Geometric Average: $GR_1 = \left[\prod_{i=1}^{n}(1 + R_{1,i})\right]^{1/n} - 1 = \left\{(1+0.4)\left[1+(-0.1)\right]\right\}^{1/2} - 1 = 0.12249722.$ (14.1.3)

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Arithmetic v. Geometric Return

- Arithmetic average (AR) is biased high

$ActBias_1 = AR_1 - GR_1 = 0.15 - 0.12249722 = 0.02750278.$

- Geometric return estimate (Taylor Series)

$$EstBias_1 = AR_1 - \ln(1 + AR_1) + \frac{\sigma_1^2}{2(1 + AR_1)^2},$$

$EstBias_1 = 0.15 - \ln(1 + 0.15) + 0.25^2/[2(1+0.15)^2]$
$= 0.15 - 0.13976194 + 0.02362949 = 0.03386755.$

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Return Contribution

- Geometric return estimate

$$EstGR_1 = \ln(1 + AR_1) - \frac{\sigma_1^2}{2(1 + AR_1)^2} = \ln(1+0.15) - \frac{0.25^2}{2(1+0.15)^2} = 0.11613245.$$

- Thus, the return contribution is

$$RC_p = \sum_{j=1}^{n} w_j RC_j = \sum_{j=1}^{n} w_j\left[\frac{AR_j}{AR_p}\ln(1 + AR_p) - \frac{\text{cov}(R_j, R_p)}{2(1 + AR_p)^2}\right] = \ln(1 + AR_p) - \frac{\sigma_p^2}{2(1 + AR_p)^2}.$$

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Simple Example Revisited

Table 14.1.3. Decomposing Estimated Geometric Returns with Simple Example

	Asset Class 1	Asset Class 2	Portfolio
Geometric Return	12.249722%	3.923048%	8.750000%
Weighted Average Geometric Return			7.045551%
Return Due to Diversification	2.129961%	0.870179%	1.704449%
Return Contribution	14.379683%	4.793228%	8.388148%
Weighted Average Return Due to Diversification			1.342598%

$RDD_j = RC_j - GR_j$ and

$RDD_p = GR_p - WAGR_p.$

$WAGR_p = \sum_{j=1}^{n} w_j GR_j.$

In practice, $WAGR_p$ is approximately equal to RDD_p.

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Table 14.1.4. Return to Diversification with Five Asset Classes

	Equity Fund	Corp Bond Fund	Interm. Bond	Internat. Fund	Small Cap Fund	Portfolio
Portfolio Weights (%)	20.00%	20.00%	20.00%	20.00%	20.00%	100.00%
Monthly Average Returns (%)	1.1240%	0.7426%	0.7230%	1.0669%	1.2043%	0.9722%
Monthly Standard Deviations (%)	4.4281%	1.8602%	1.7638%	5.0164%	6.4473%	2.9647%
Annualized Arithmetic Return	13.4882%	8.9113%	8.6765%	12.8031%	14.4522%	11.6662%
Annualized Standard Deviation	15.3392%	6.4438%	6.1101%	17.3772%	22.3340%	10.2700%
Annualized Geometric Return	12.2498%	8.6755%	8.4633%	11.2526%	11.8543%	11.0907%
Weighted Average Geometric Return						10.4991%
Return Due to Diversification	0.4820%	0.0229%	0.0380%	0.8693%	1.5641%	0.5916%
Return Contribution	12.7318%	8.6984%	8.5014%	12.1220%	13.4183%	11.0944%
Covar(j, Portfolio)	0.001175	0.000289	0.000226	0.001052	0.001638	0.000876
Weighted Average Return Due to Diversification						0.59526%

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Summary

- Provide several perspectives on portfolio risk
- Examine nine stocks and nine sector ETFs
- Contrast with SPY, passive index ETF
- Illustrate marginal analysis of risk
- Introduce diversification benefits
  - Volatility benefits
  - Return due to diversification

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