

# Introduction to Risk Parity and Budgeting

## Chapter 6 – Portfolio Allocation with Multi-Asset Classes

© Thierry Roncalli<sup>†</sup> & CRC Press

<sup>†</sup> Evry University & Lyxor Asset Management, France

Instructors may find the description of the book at the following addresses:

<http://www.crcpress.com/product/isbn/9781482207156>

<http://www.thierry-roncalli.com/RiskParityBook.html>

May 22, 2013

Figure: Asset allocation puzzle of diversification funds

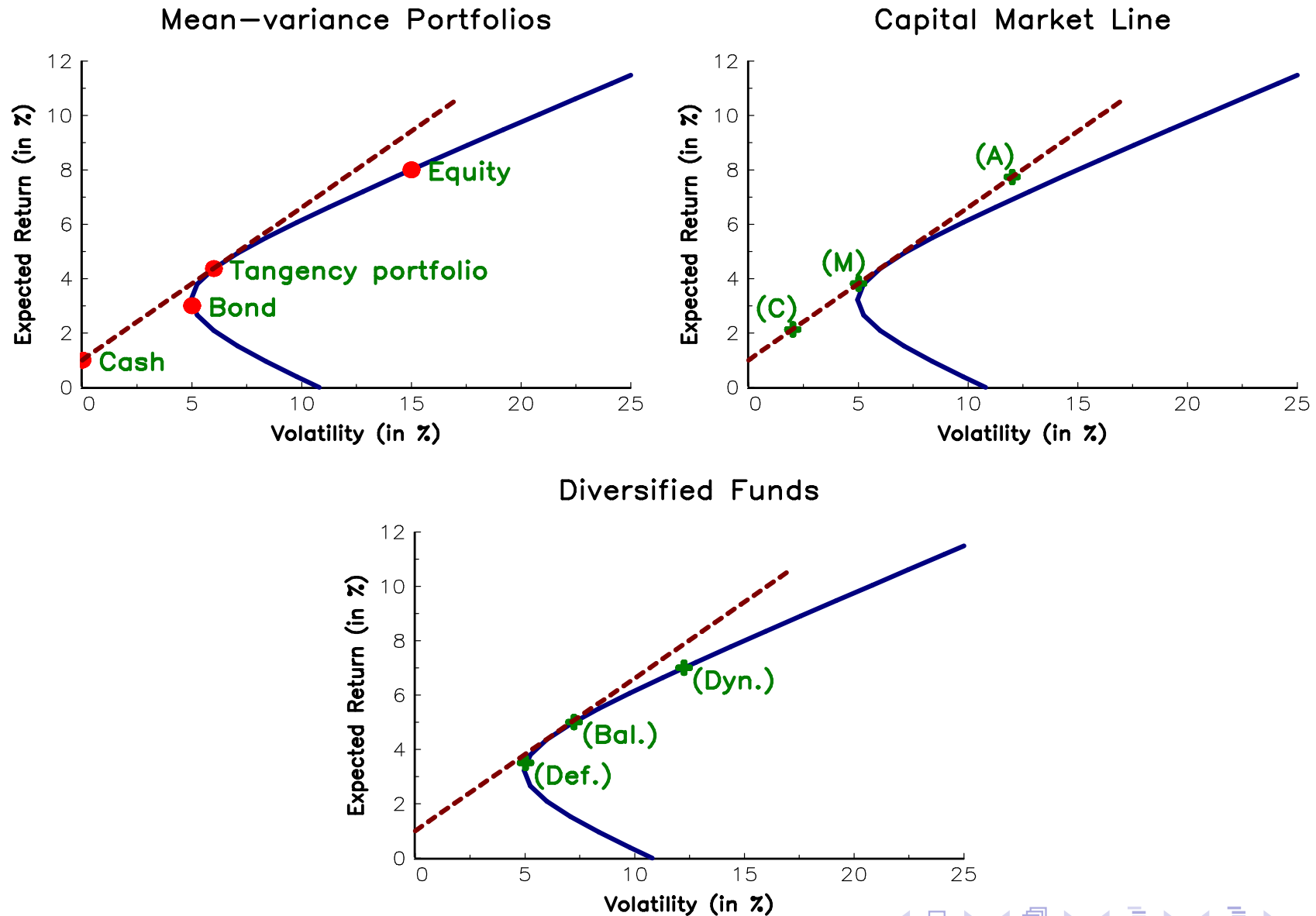


Figure: Equity and bond risk contributions in diversified funds

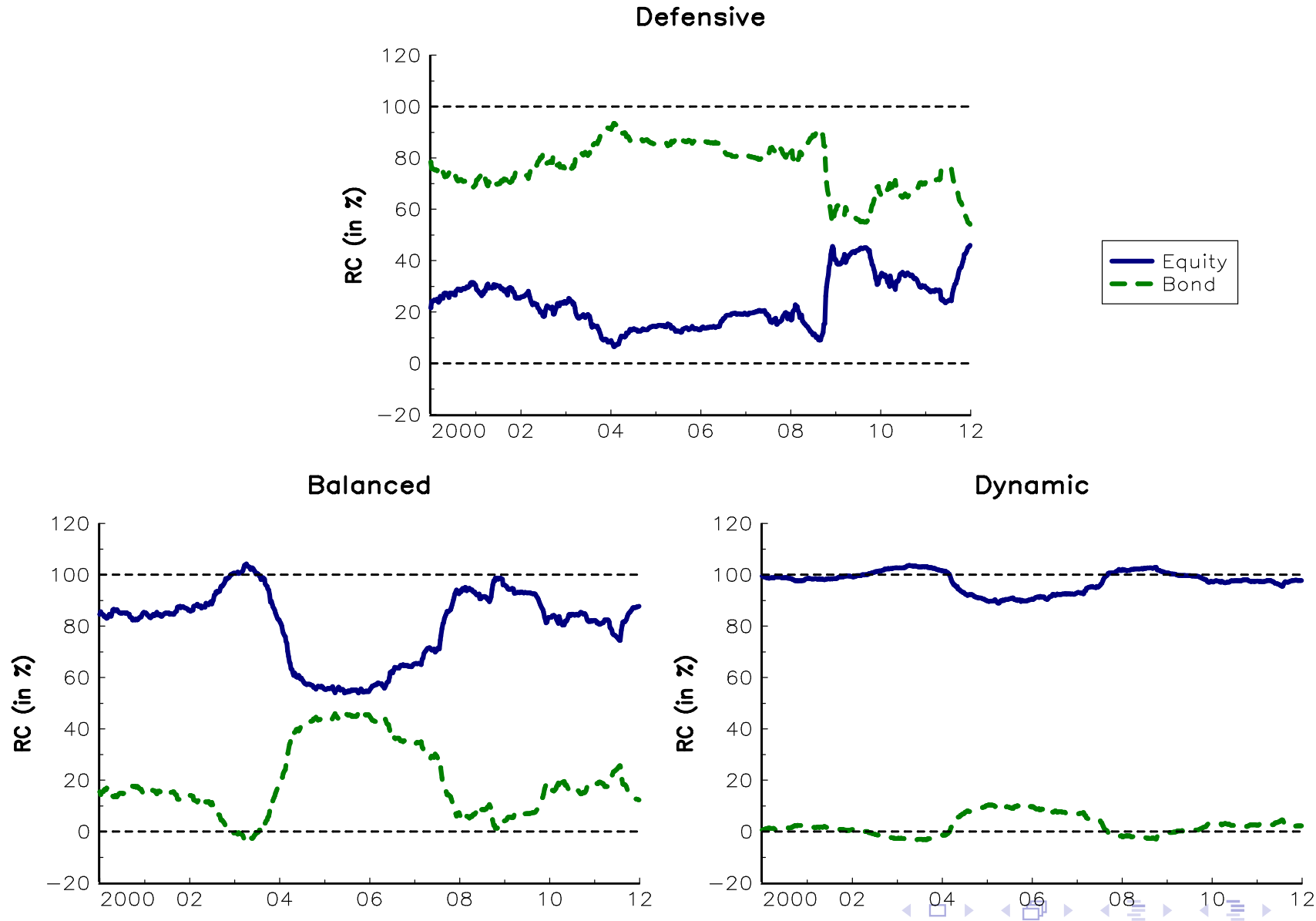
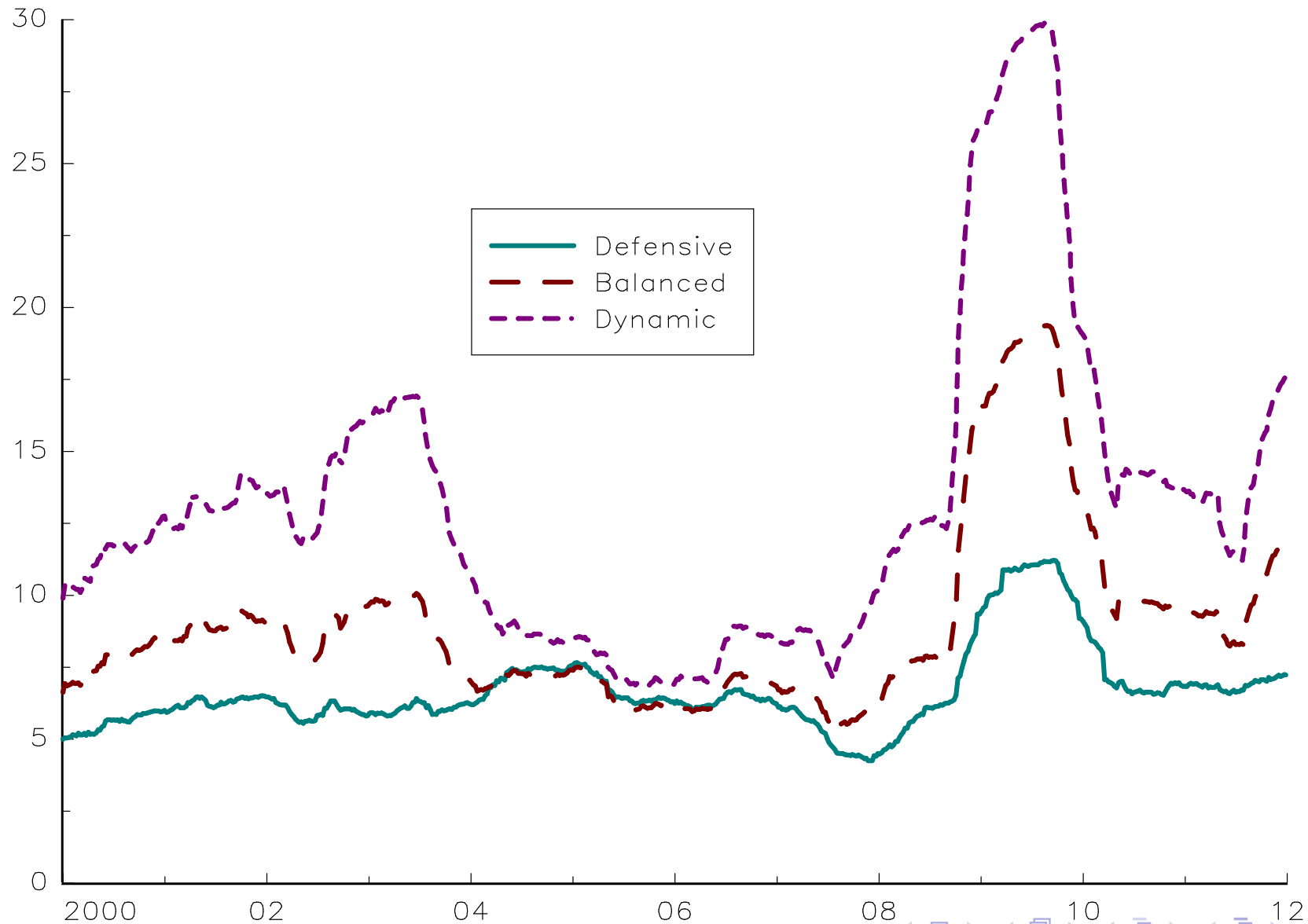


Figure: Realized volatility of diversified funds (in %)



**Table:** Mean and standard deviation of the ex-ante risk premium for diversified funds (in %)

Asset	$\hat{\mu}(\tilde{\pi})$			$\hat{\sigma}(\tilde{\pi})$		
	Def.	Bal.	Dyn.	Def.	Bal.	Dyn.
Equity	2.05	3.71	4.02	20.68	28.19	28.26
Bond	1.57	0.77	0.26	4.05	7.37	7.56

Figure: Equity and bond ex-ante risk premia for diversified funds

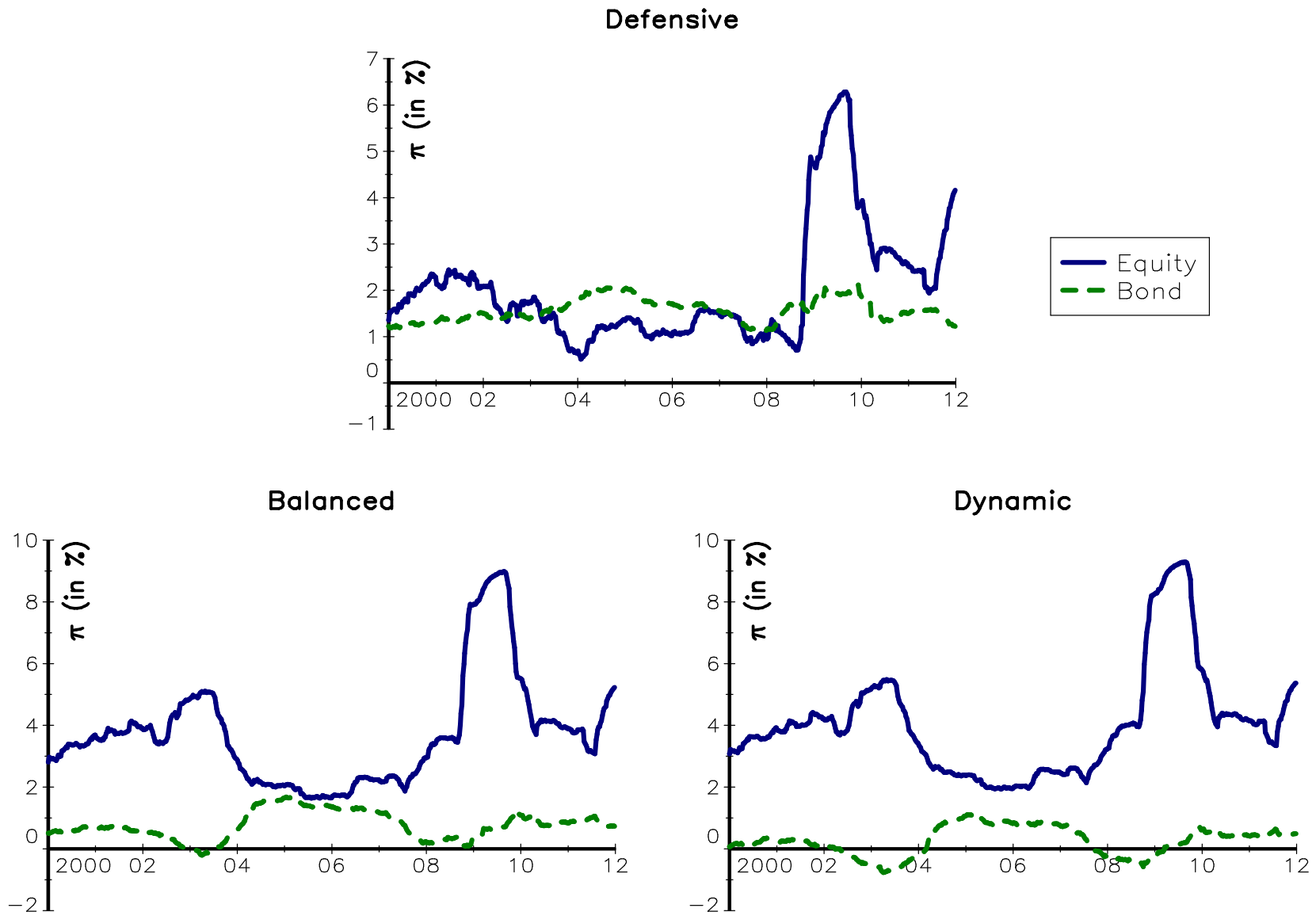


Figure: Histogram of ex-ante performance contributions

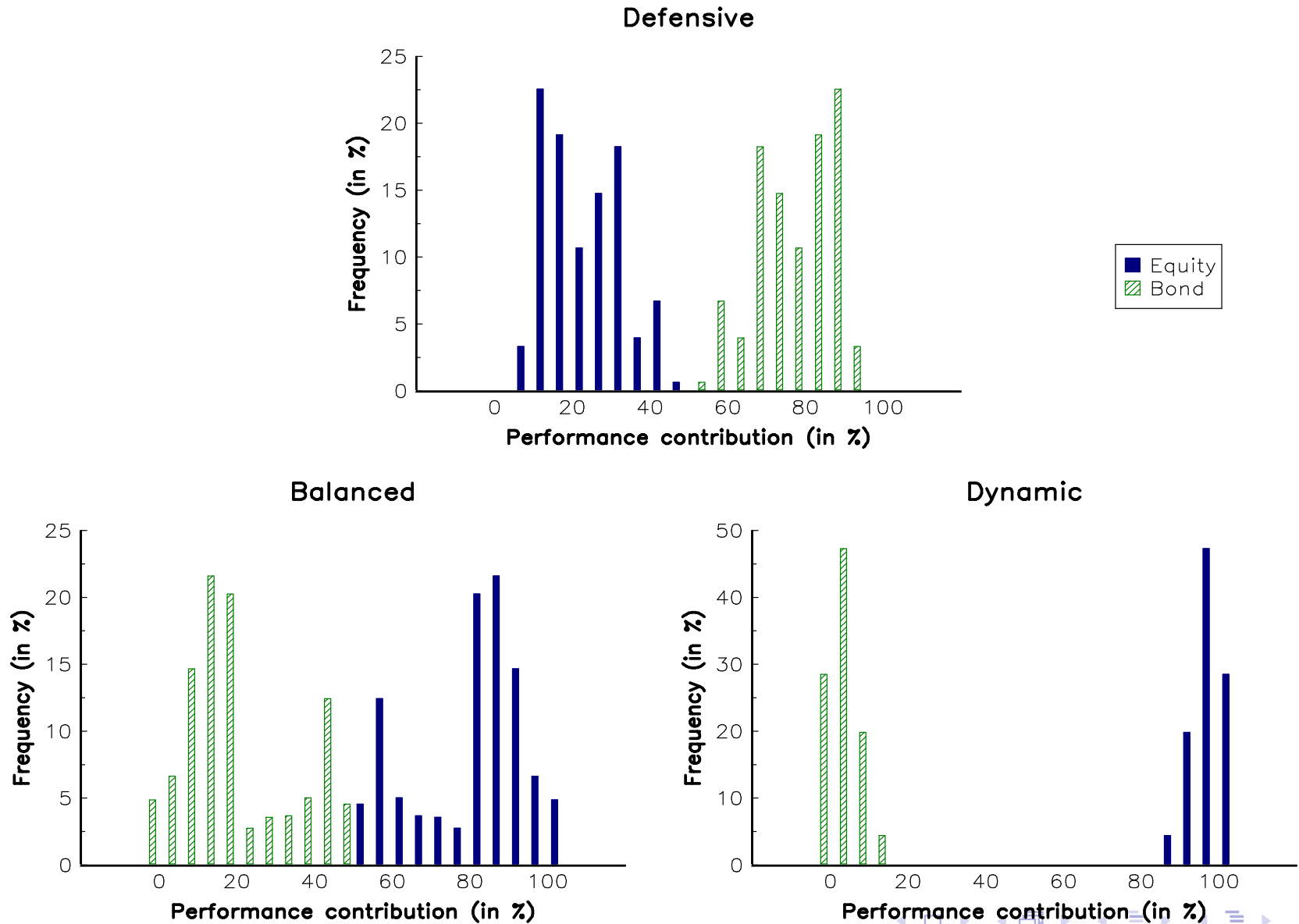


Figure: Influence of the correlation on the expected risk premium

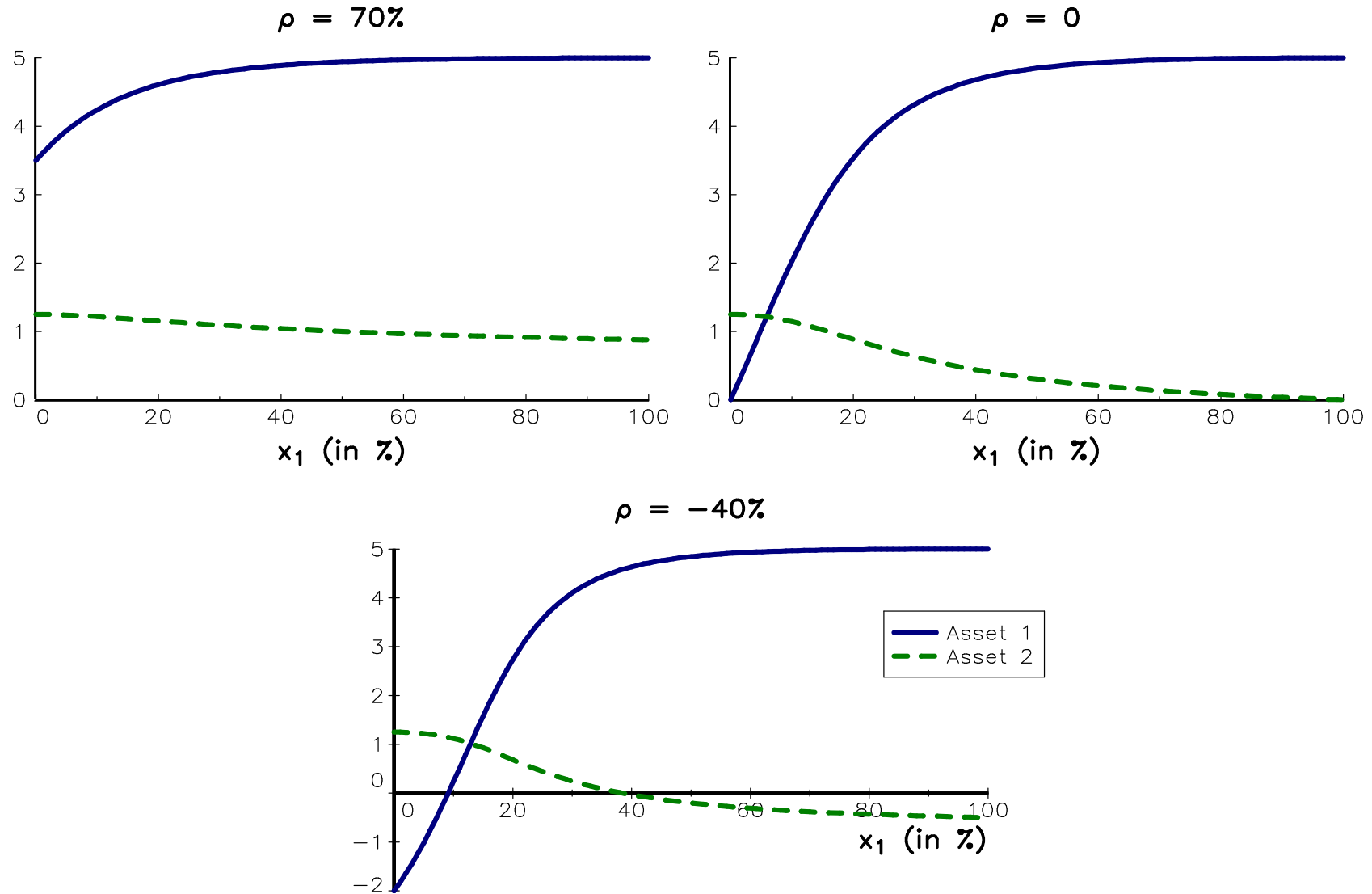




Table: Statistics of diversified and risk parity portfolios

Portfolio	$\hat{\mu}_{1Y}$	$\hat{\sigma}_{1Y}$	SR	$\mathcal{MDD}$	$\gamma_1$	$\gamma_2$
Defensive	5.41	6.89	0.42	-17.23	0.19	2.67
Balanced	3.68	9.64	0.12	-33.18	-0.13	3.87
Dynamic	1.70	14.48	-0.06	-48.90	-0.18	5.96
Risk parity	5.12	7.29	0.36	-21.22	0.08	2.65
Static	4.71	7.64	0.29	-23.96	0.03	2.59
Leveraged RP	6.67	9.26	0.45	-23.74	0.01	0.78

Figure: Backtest of the risk parity strategy

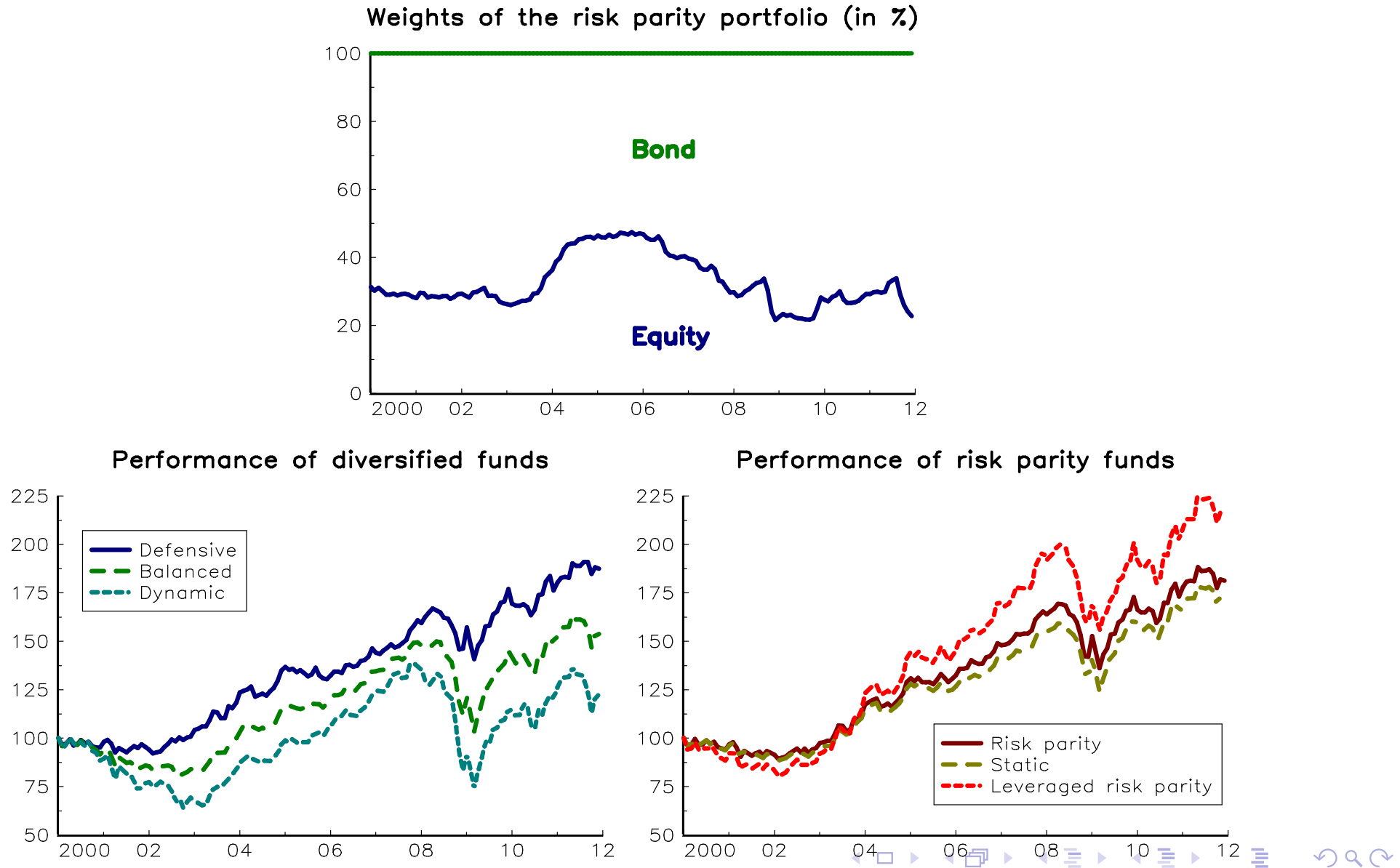


Figure: Relationship between the beta  $\beta_i$  and the alpha  $\alpha_i$  in the presence of borrowing constraints

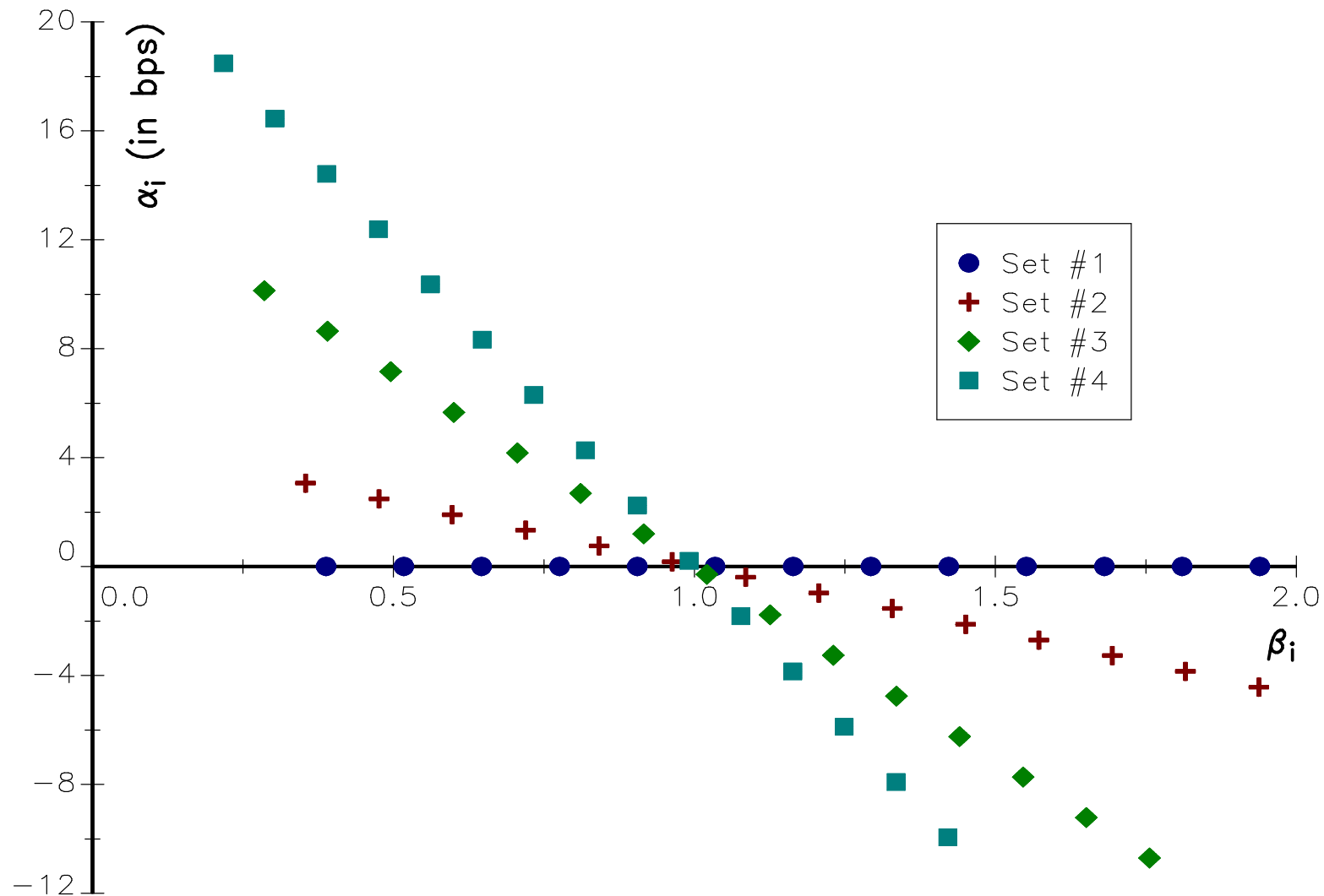


Figure: Impact of leverage aversion on the efficient frontier

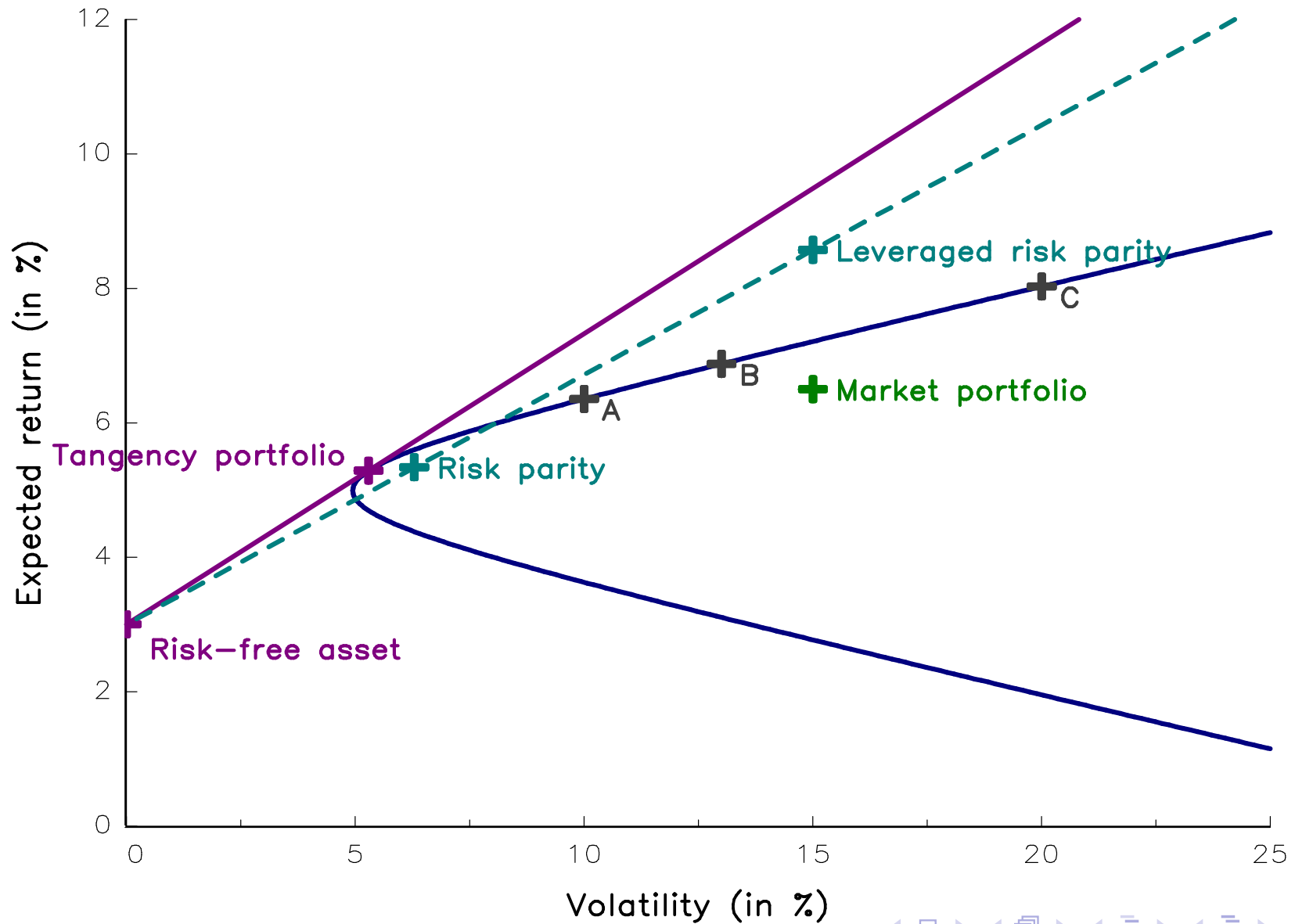
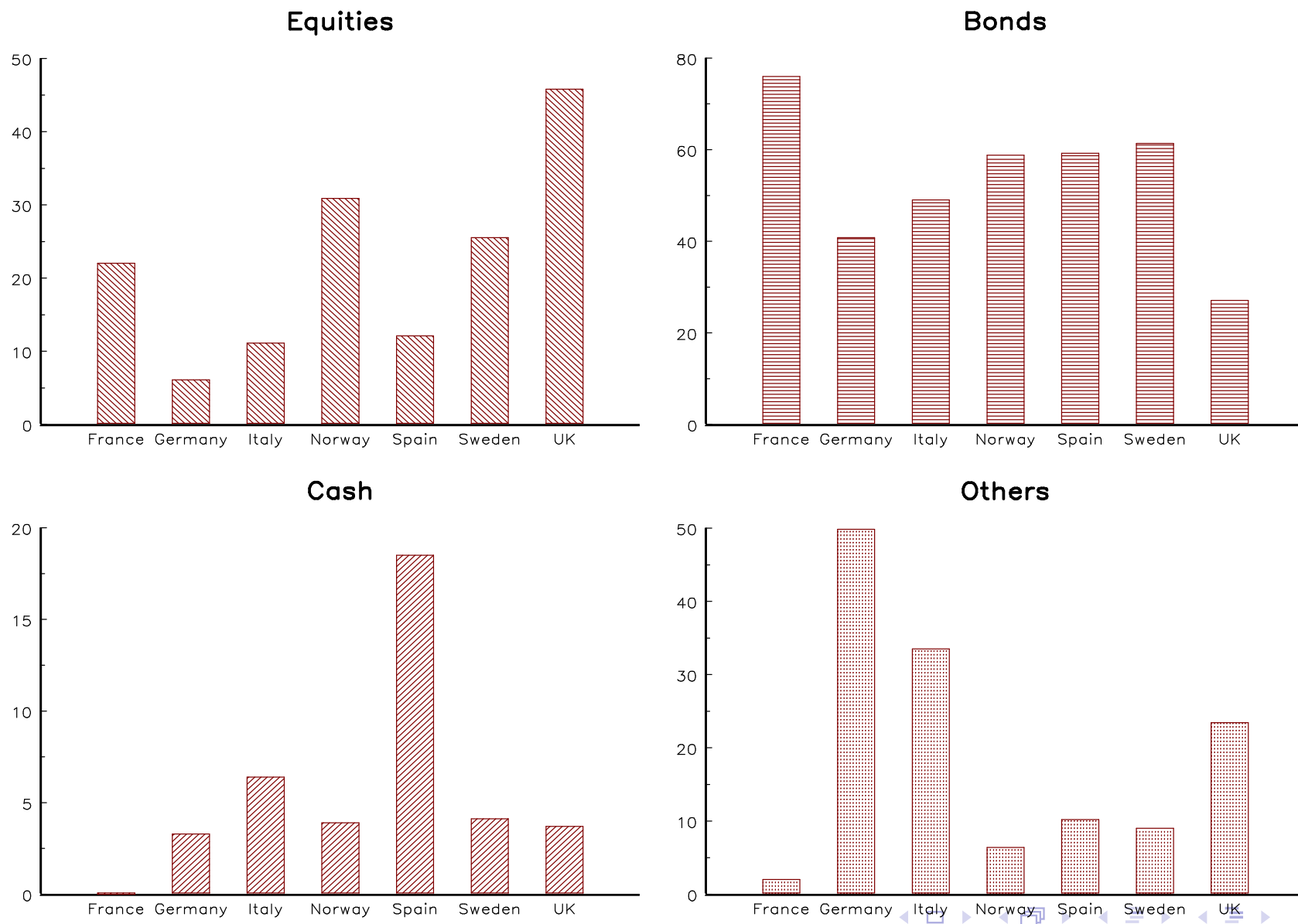


Figure: Average allocation of European pension funds



# Tables 6.3 & 6.4, Pages 287 & 288

**Table:** Expected returns and risks for the SAA approach (in %)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\mu_i$	4.2	3.8	5.3	10.4	9.2	8.6	5.3	11.0	8.8
$\sigma_i$	5.0	5.0	7.0	10.0	15.0	15.0	15.0	18.0	30.0

**Table:** Correlation matrix of asset returns for the SAA approach (in %)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)	100								
(2)	80	100							
(3)	60	40	100						
(4)	-20	-20	50	100					
(5)	-10	-20	30	60	100				
(6)	-20	-10	20	60	90	100			
(7)	-20	-20	20	50	70	60	100		
(8)	-20	-20	30	60	70	70	70	100	
(9)	0	0	10	20	20	20	30	30	100

Figure: Risk budgeting policy of the pension fund (SAA approach)

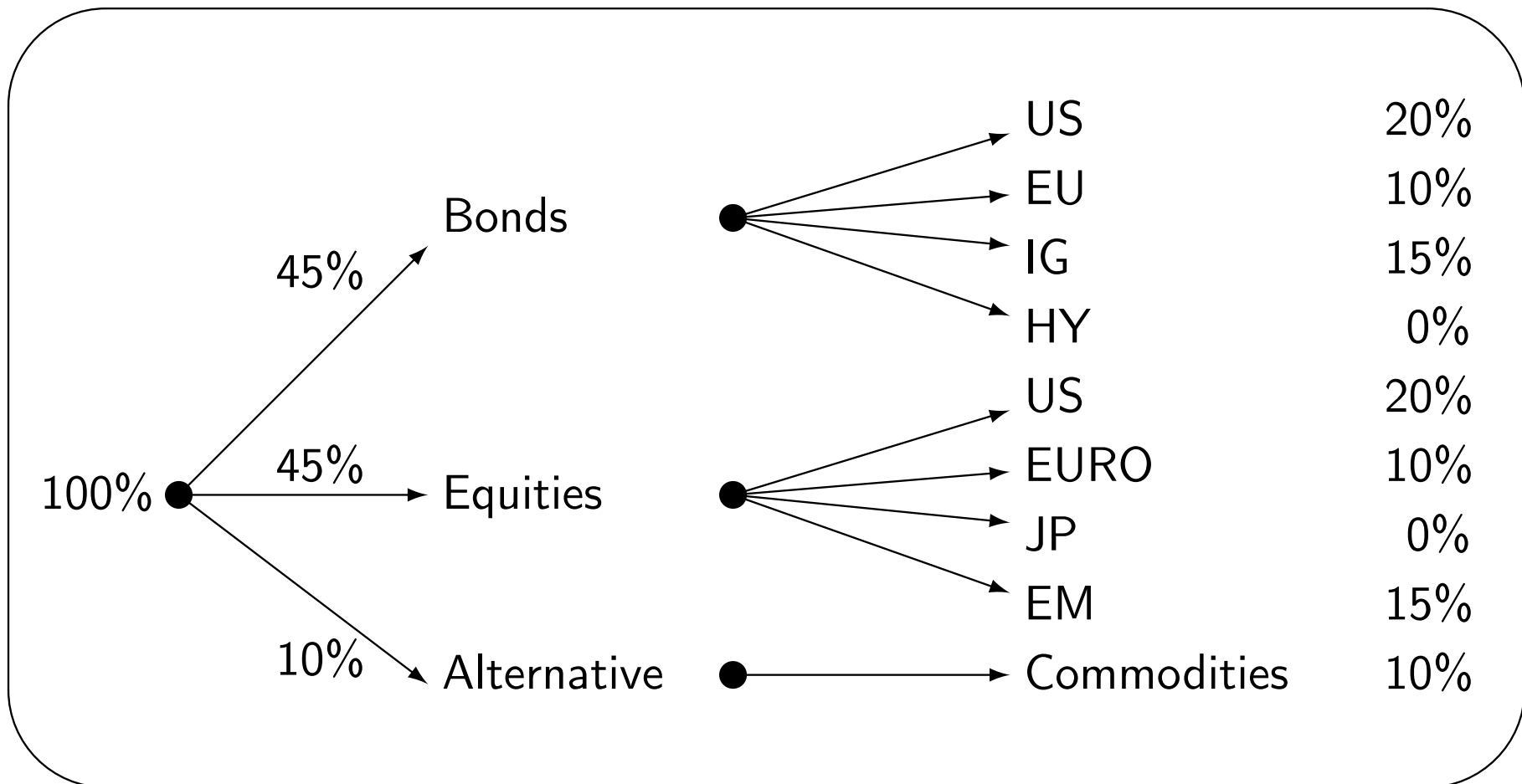


Figure: Strategic asset allocation in Markowitz framework

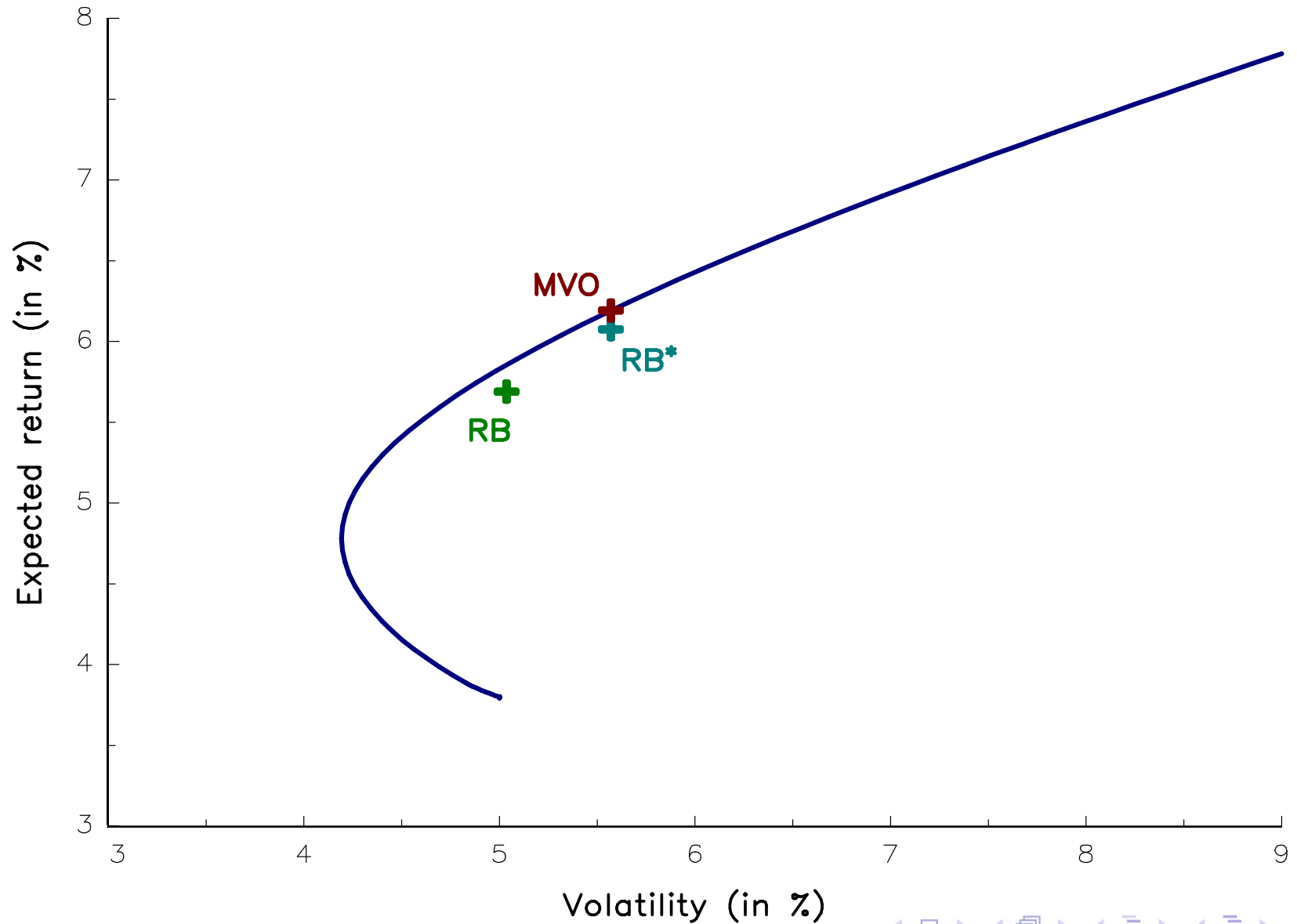




Table: Long-term strategic portfolios

Asset class	RB		RB*		MVO	
	$x_i$	$RC_i^*$	$x_i$	$RC_i^*$	$x_i$	$RC_i^*$
(1)	36.8%	20.0%	45.9%	18.1%	66.7%	25.5%
(2)	21.8%	10.0%	8.3%	2.4%	0.0%	0.0%
(3)	14.7%	15.0%	13.5%	11.8%	0.0%	0.0%
(5)	10.2%	20.0%	10.8%	21.4%	7.8%	15.1%
(6)	5.5%	10.0%	6.2%	11.1%	4.4%	7.6%
(8)	7.0%	15.0%	11.0%	24.9%	19.7%	49.2%
(9)	3.9%	10.0%	4.3%	10.3%	1.5%	2.7%

Table: Weights of the SAA portfolios

Asset class	Region	#1	#2	#3	#4
Equity	US	20%	10%	30%	19.0%
	EU	20%	10%	30%	21.7%
	UK	5%		10%	6.2%
	JP	5%		10%	2.3%
Sovereign Bonds	US	10%	20%	10%	
	EU	5%	15%	10%	5.9%
	UK	5%	5%		
	JP	5%	5%		
Corporate Bonds	US	5%	5%		24.1%
	EU	5%	5%		10.7%
High Yield	US	5%	5%		2.6%
	EU	5%	5%		7.5%
TIPS	US	5%	15%		

**Table:** Risk contributions of SAA portfolios with respect to economic factors

Factor	#1	#2	#3	#4
Activity	36.91%	19.18%	51.20%	34.00%
Inflation	12.26%	4.98%	9.31%	20.00%
Interest rate	42.80%	58.66%	32.92%	40.00%
Currency	7.26%	13.04%	5.10%	5.00%
Residual factors	0.77%	4.14%	1.47%	1.00%

**Table:** Estimate of the loading matrix  $A$  (Jan. 1992 – Jun. 2012)

	MKT	SMB	HML	MOM
CW	0.98	-0.26	-0.06	-0.01
EW	0.99	-0.08	0.22	-0.13
MV	0.58	-0.16	0.18	-0.03
MDP	0.80	-0.04	0.21	-0.11
ERC	0.87	-0.11	0.24	-0.09

**Table:** Risk contributions of risk-based S&P 100 indices with respect to economic factors (Q1 1992 – Q2 2012)

Factor	CW	EW	MV	MDP	ERC
Activity	71.7%	70.0%	29.4%	41.8%	62.1%
Inflation	21.8%	16.7%	4.7%	9.4%	9.5%
Interest rate	6.0%	12.7%	64.7%	46.9%	27.5%
Currency	0.6%	0.6%	1.2%	1.9%	0.9%

Figure: Volatility decomposition of the risk-based S&P 100 indices

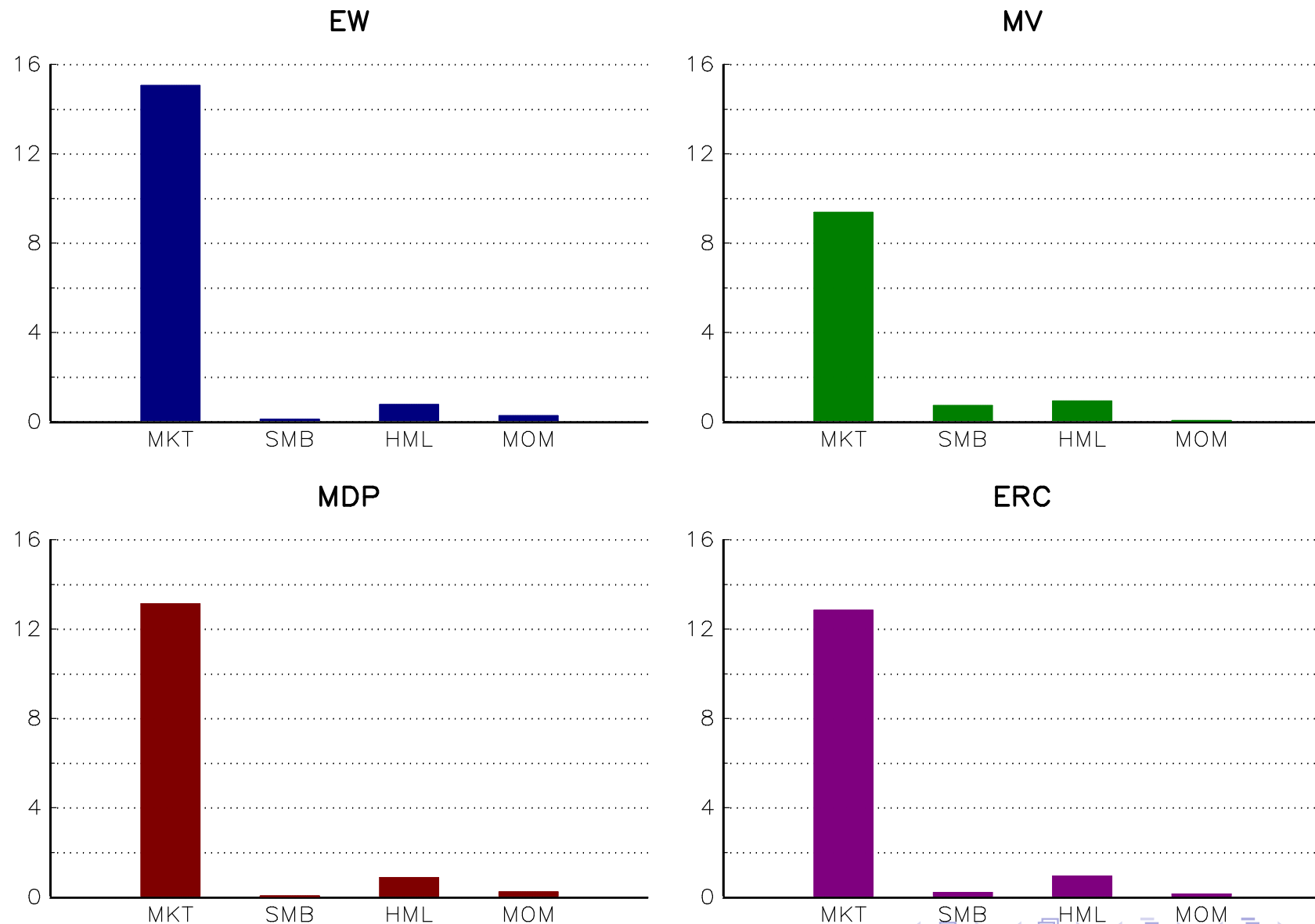


Figure: Volatility decomposition of long/short portfolios

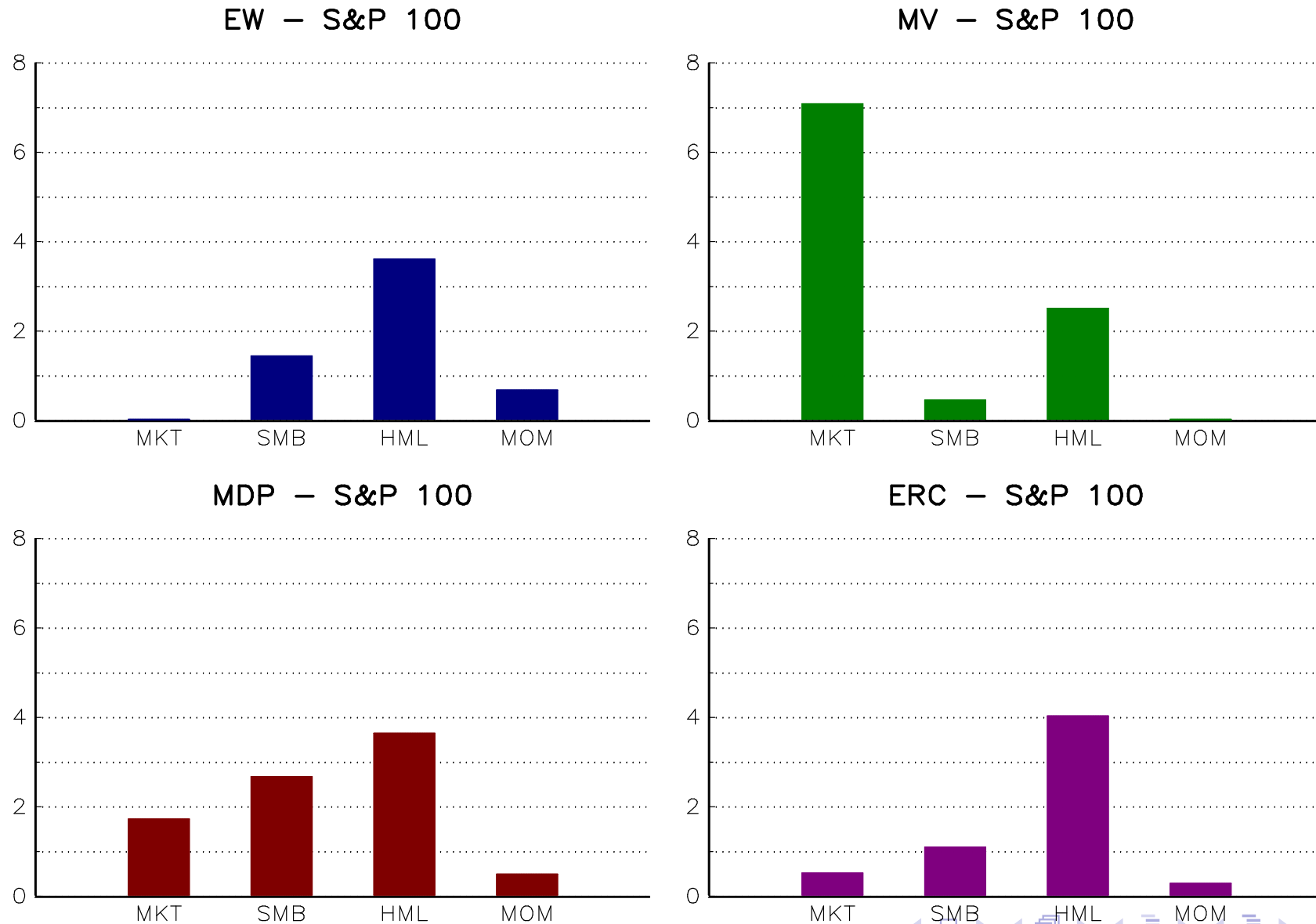


Figure: Simulated performance of the S/B risk parity strategies

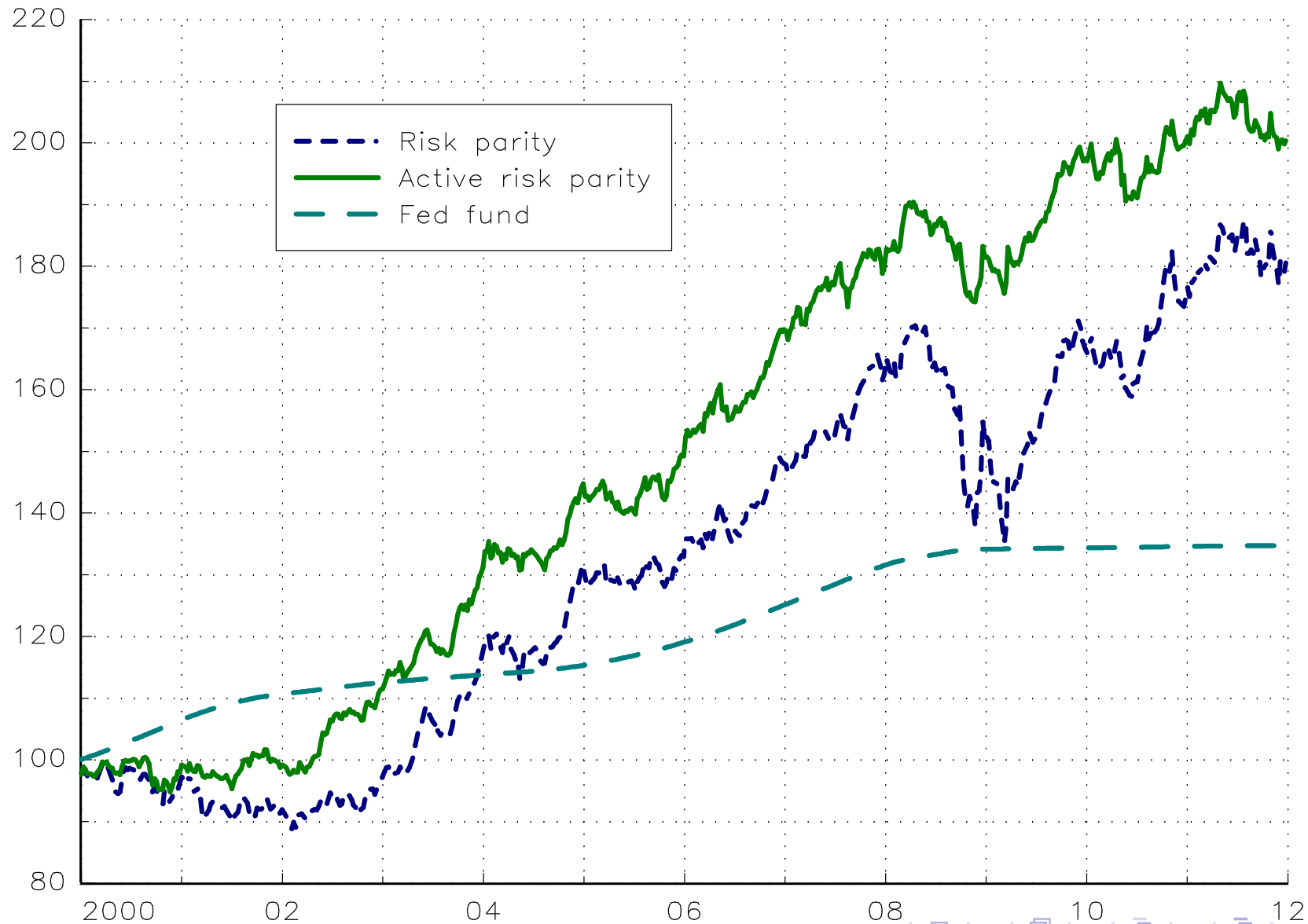


Figure: Simulated performance of the S/B/C risk parity strategies

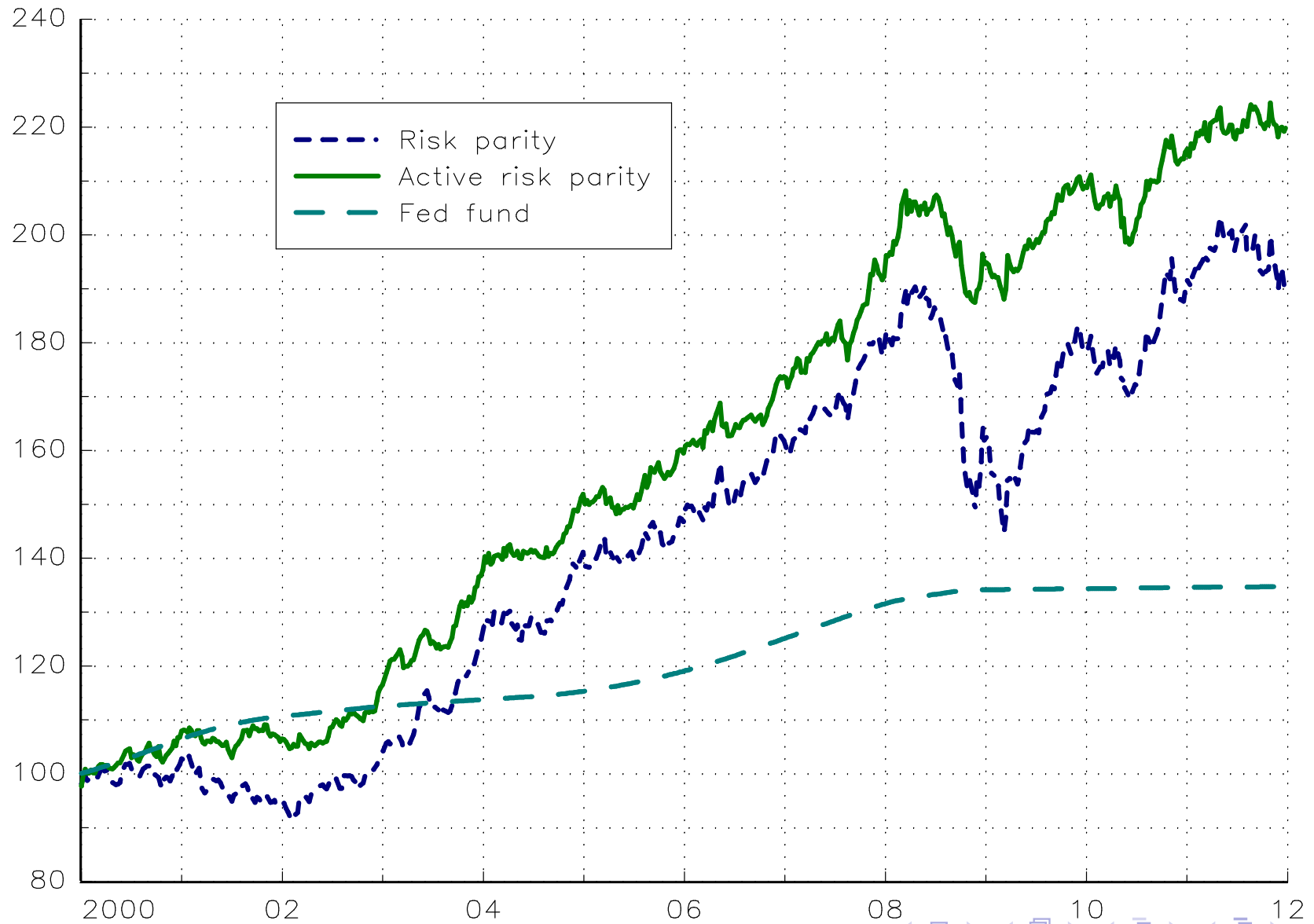




Table: Statistics of active risk parity strategies

AC	Strategy	$\hat{\mu}_{1Y}$	$\hat{\sigma}_{1Y}$	SR	$\mathcal{MDD}$	$\gamma_1$	$\gamma_2$	$\tau$
S/B	RP	5.10	7.30	0.35	-21.39	0.07	2.68	0.30
	ARP	5.99	5.16	0.67	-9.35	0.02	2.11	4.92
S/B/C	RP	5.67	7.36	0.43	-24.55	0.01	3.29	0.39
	ARP	6.82	5.10	0.84	-10.21	0.05	1.93	6.74