



DIVERSIFICATION and the VOLATILITY RISK PREMIUM

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Wells Fargo Asset Management is a trade name used by the asset management businesses of Wells Fargo & Company.



Volatility Risk Premium (VRP)

❑ **VRP = Risk Neutral Volatility of Asset – E(Volatility)**

❑ \approx Option Implied Volatility – E(Volatility)

❑ \cong Option Implied Volatility – Actual Volatility

❑ **Complexities in Calculation**

❑ Calculation of implied volatility

❑ Time Horizon

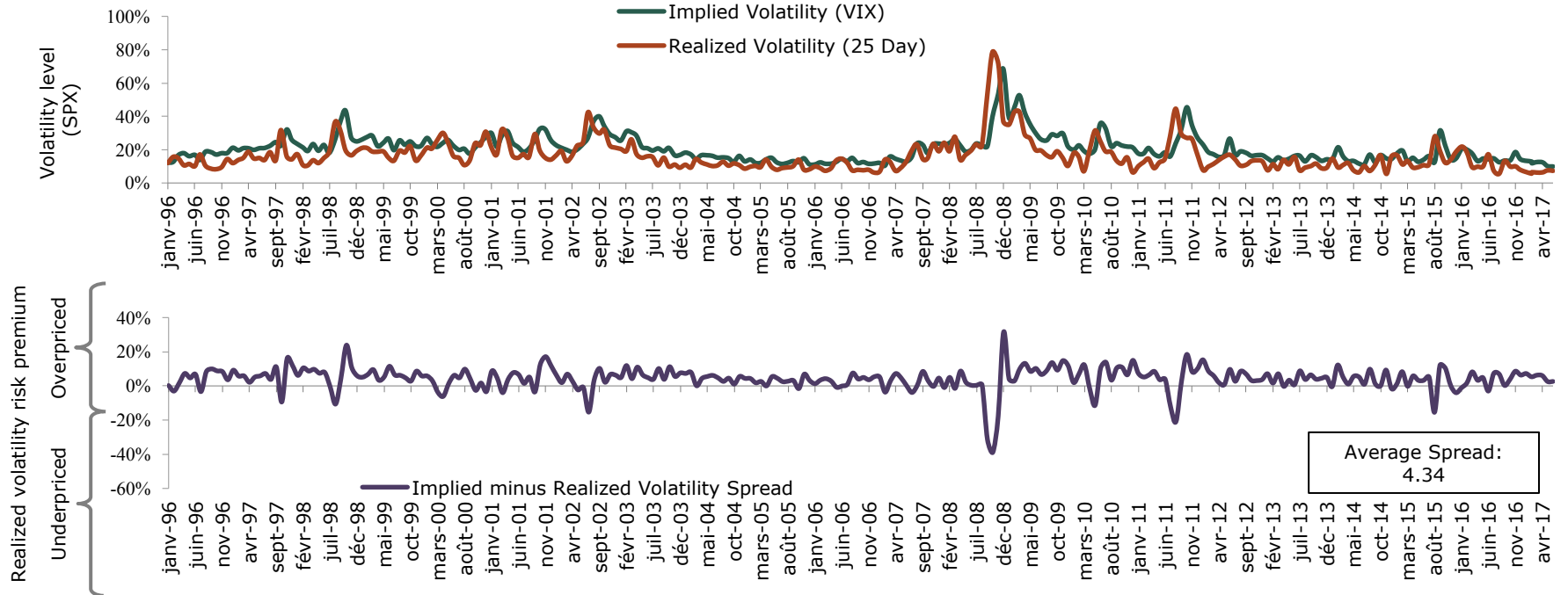
❑ **Rationale: Compensation for “sellers” of volatility for the bearing the risk between high levels of uncertainty**

Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, “Diversification and the Volatility Risk Premium” chapter in *Risk-Based and Factor Investing* (September 2018).

Realized VRP for S&P500

The market tends to consistently overprice volatility

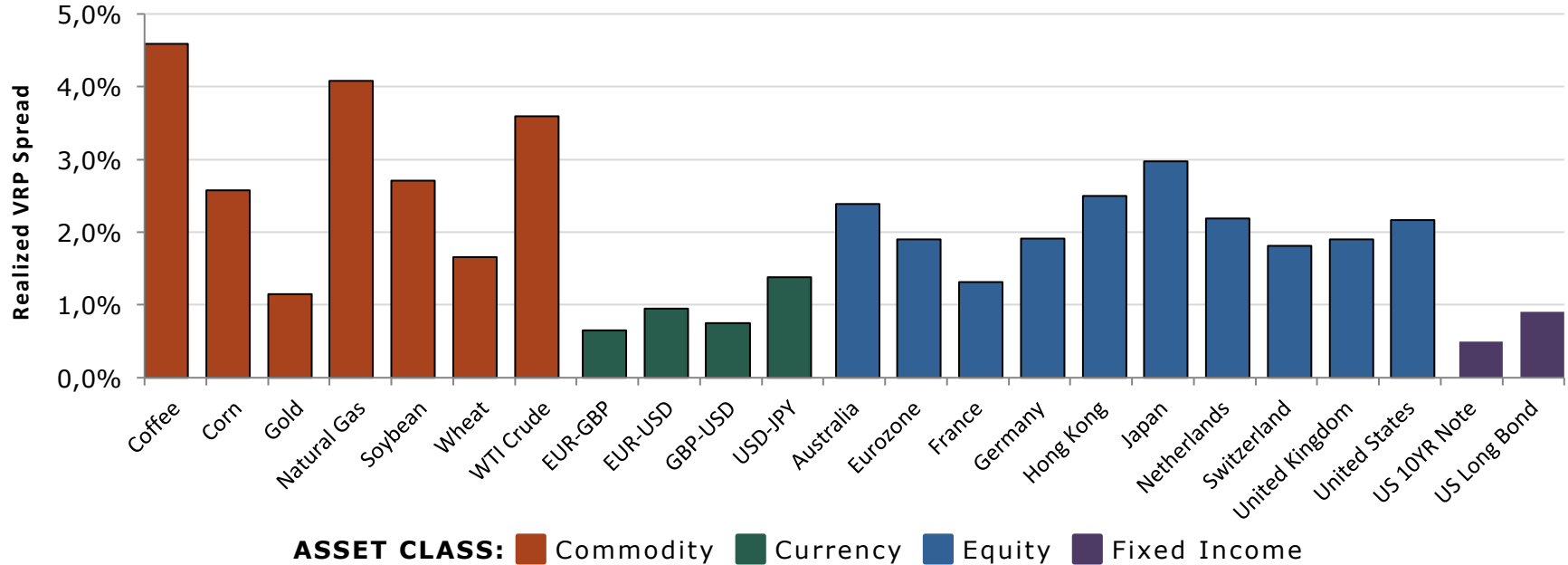
January 1996 – June 2017



Source: Bloomberg.

Median VRP Spread

January 2006 – May 2016



Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

Volatility Risk Premia in Equity, Fixed Income, Currency and Commodity Markets

Exposure	Bloomberg Ticker	Implied Volatility	Realized Volatility	VRP Mean	VRP Median	VRP Standard Deviation	VRP Skewness	VRP Kurtosis
Commodity Coffee	KC1 Comdty	34.4%	30.2%	4.2%	4.6%	8.3%	-0.9	4.4
Commodity Corn	C 1 Comdty	31.0%	28.9%	2.1%	2.6%	7.9%	-0.3	1.0
Commodity Gold	GC1 Comdty	19.7%	18.8%	0.9%	1.1%	5.8%	-1.1	5.8
Commodity Natural Gas	NG1 Comdty	49.8%	45.4%	4.4%	4.1%	12.6%	0.1	3.8
Commodity Soybean	S 1 Comdty	25.4%	23.1%	2.3%	2.7%	6.2%	-0.4	1.0
Commodity Wheat	W 1 Comdty	33.5%	32.3%	1.2%	1.7%	8.6%	-0.2	1.2
Commodity WTI Crude	CL1 Comdty	36.3%	33.6%	2.7%	3.6%	10.4%	-0.4	3.8
Currency EUR-GBP	EURGBP Curncy	8.2%	7.7%	0.5%	0.7%	1.7%	-0.3	1.8
Currency EUR-USD	EURUSD Curncy	10.1%	9.3%	0.9%	0.9%	2.1%	-0.4	2.1
Currency GBP-USD	GBPUSD Curncy	9.2%	8.5%	0.7%	0.8%	2.0%	-0.5	2.8
Currency USD-JPY	USDJPY Curncy	10.6%	9.7%	1.0%	1.4%	3.2%	-0.8	1.5
Equity Australia	AS51 Index	18.5%	16.7%	1.9%	2.4%	6.4%	-1.6	8.5
Equity Eurozone	SX5E Index	22.2%	21.6%	0.6%	1.9%	7.6%	-2.2	8.5

Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

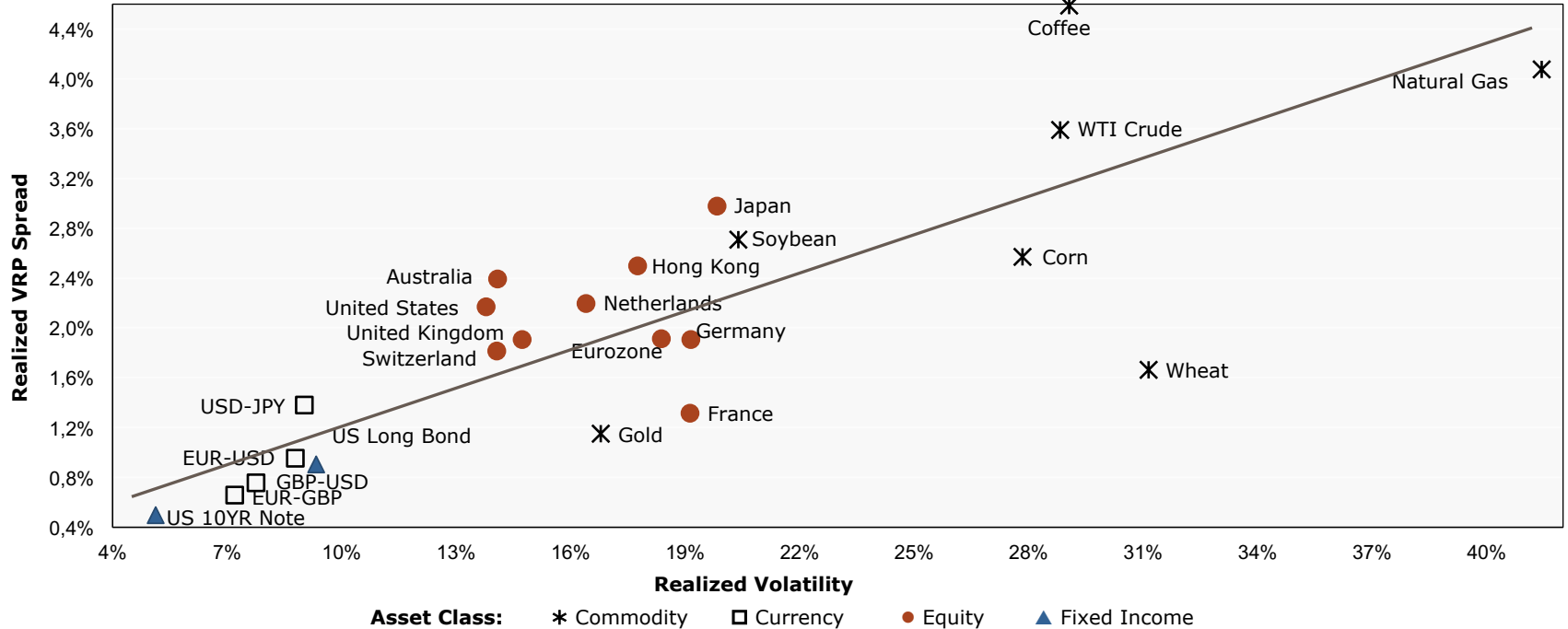
Volatility Risk Premia in Equity, Fixed Income, Currency and Commodity Markets (cont.)

Exposure	Bloomberg Ticker	Implied Volatility	Realized Volatility	VRP Mean	VRP Median	VRP Standard Deviation	VRP Skewness	VRP Kurtosis
Equity France	CAC Index	21.6%	21.4%	0.1%	1.3%	7.6%	-2.4	10.2
Equity Germany	DAX Index	21.5%	20.8%	0.7%	1.9%	7.1%	-2.3	9.9
Equity Hong Kong	HSI Index	24.0%	22.3%	1.7%	2.5%	8.7%	-1.8	10.7
Equity Japan	NKY Index	23.7%	22.5%	1.2%	3.0%	10.0%	-2.2	11.7
Equity Netherlands	AEX Index	20.3%	19.4%	0.9%	2.2%	7.6%	-3.1	16.5
Equity Switzerland	SMI Index	17.2%	16.5%	0.7%	1.8%	7.3%	-2.4	11.0
Equity United Kingdom	UKX Index	18.2%	17.2%	0.9%	1.9%	6.8%	-2.5	12.8
Equity United States	SPX Index	18.0%	17.0%	1.0%	2.2%	7.4%	-3.2	16.6
Fixed Income US 10YR Note	TY1 Comdty	6.1%	5.7%	0.4%	0.5%	1.5%	-1.0	6.4
Fixed Income US Long Bond	US1 Comdty	10.7%	10.0%	0.7%	0.9%	2.3%	-0.4	3.4

Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

VRP Spread vs Realized Volatility (2006-2016)

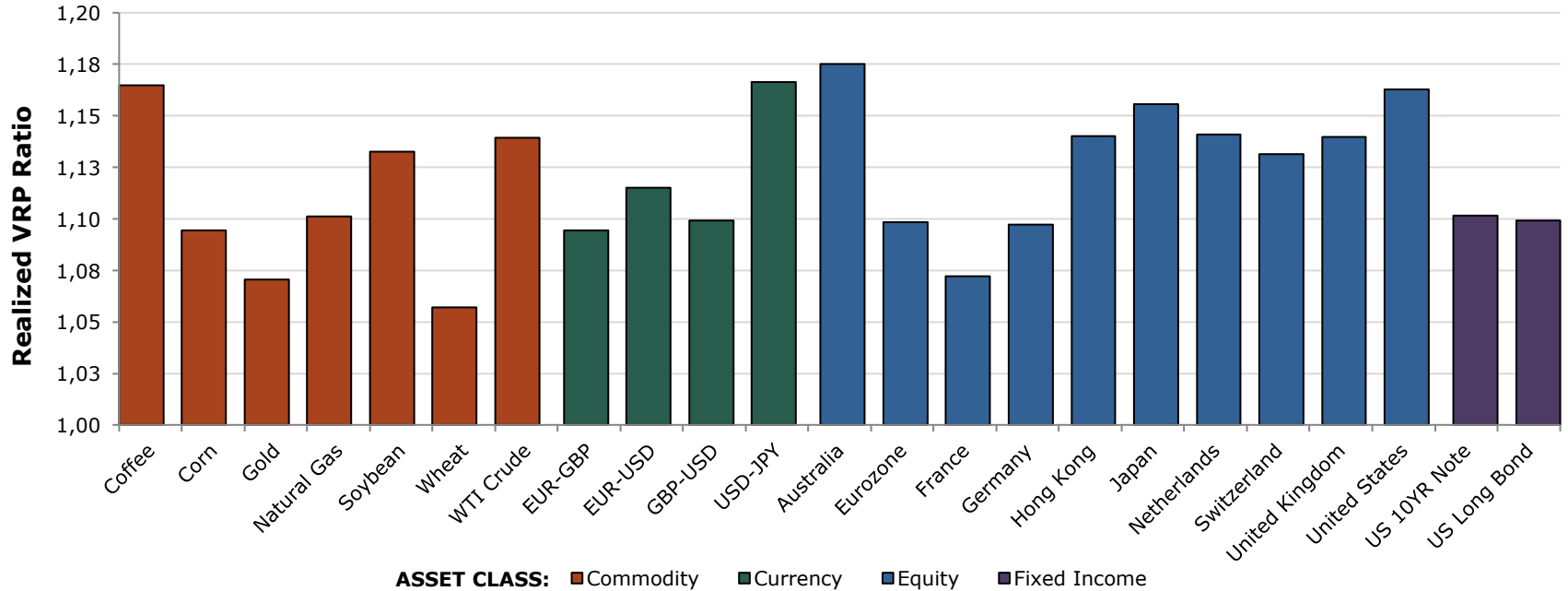
January 2006 – May 2016



Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

Median VRP Ratios

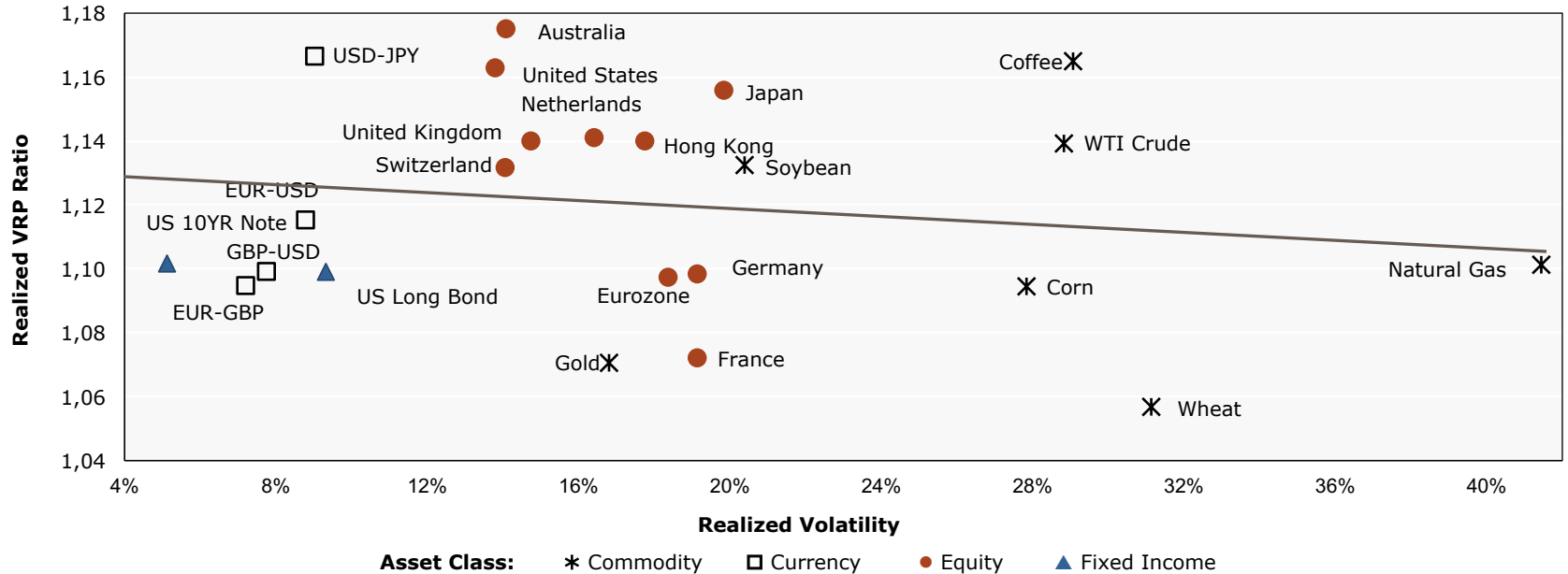
January 2006 – May 2016



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VRP Ratio vs Realized Volatility (2006-2016)

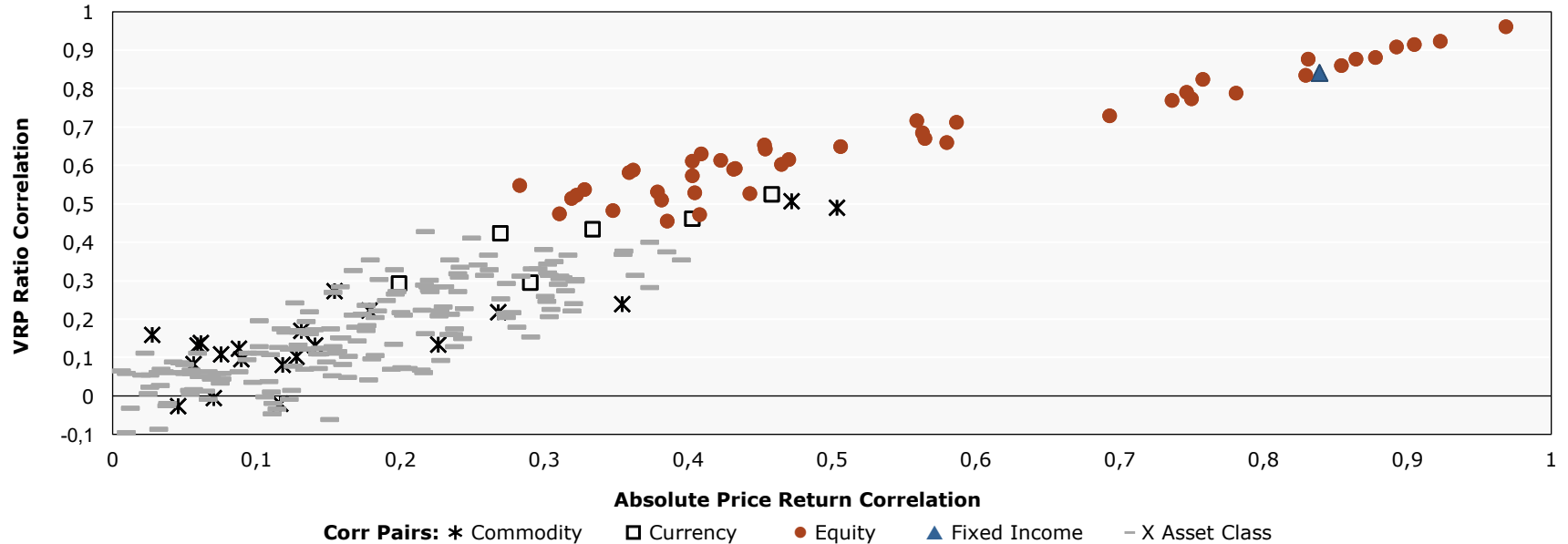
January 2006 – May 2016



Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

VRP Ratio Correlation vs Return Correlation

January 2006 – May 2016



Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

Risk and Return of VRP Portfolios

January 2006 – May 2016

	Equity VRP	Commodity VRP	Currency VRP	Fixed Income VRP	Equal Asset VRP	Equal Asset Class VRP
Annualized Excess Return	4.38%	13.45%	19.97%	17.38%	11.25%	14.17%
Annualized Risk	15.48%	9.72%	13.72%	16.25%	10.83%	10.47%
Sharpe Ratio	0.28	1.38	1.46	1.07	1.04	1.35

Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

Regression of Portfolio Excess Returns on Pure Factor Portfolios

$$\begin{aligned} \text{VRP Portfolio} = & \text{Intercept} + \text{Coeff}_{\text{Market}} \times \text{Market} + \text{Coeff}_{\text{Value}} \times \text{Value} + \text{Coeff}_{\text{Momentum}} \times \text{Momentum} \\ & + \text{Coeff}_{\text{Small Size}} \times \text{Small Size} + \text{Coeff}_{\text{Low Beta}} \times \text{Low Beta} + \text{Coeff}_{\text{Profitability}} \times \text{Profitability} \\ & + \text{Coeff}_{\text{Bond Beta}} \times \text{Bond Beta} + \varepsilon \end{aligned}$$

January 2006 – May 2016

	Equity VRP	Commodity VRP	Currency VRP	Fixed Income VRP	Equal Asset Class VRP
R Square	0.55	0.14	0.19	0.18	0.41
Intercept (t stat)	-0.04 (-0.13)	1.13 (4.36)**	1.44 (4.08)**	1.03 (2.45)*	0.89 (3.86)**
Market (t stat)	0.61 (6.31)**	-0.01 (-0.09)	0.19 (1.63)	0.42 (3.06)**	0.30 (4.03)**
Value (t stat)	-0.99 (-2.11)*	0.18 (0.43)	-0.71 (-1.27)	-1.35 (-2.04)*	-0.72 (-1.98)*
Momentum (t stat)	0.53 (2.35)*	-0.05 (-0.27)	-0.05 (-0.17)	0.39 (1.22)	0.20 (1.17)
Small Size (t stat)	0.52 (1.61)	0.32 (1.13)	0.15 (0.39)	0.63 (1.39)	0.41 (1.62)
Low Beta (t stat)	-0.35 (-1.26)	-0.57 (-2.37)*	-0.59 (-1.79)	0.12 (0.30)	-0.35 (-1.62)
Profitability (t stat)	0.13 (0.33)	-0.29 (-0.86)	0.06 (0.12)	0.34 (0.62)	0.06 (0.19)
Bond Beta (t stat)	-0.55 (-2.05)*	-0.43 (-1.85)	-0.38 (-1.20)	0.03 (0.07)	-0.33 (-1.61)

Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).

Volatility Risk Premium (VRP)

- ❑ **Magnitude of VRP is related to underlying asset volatility – should probably be viewed in ratios as opposed to spreads**
- ❑ **Correlation between VRP across assets is very closely related to the correlation of the underlying asset returns**
 - ❑ Diversify VRP exposure using relationship between asset class returns as a guide
 - ❑ Risk parity approach is particularly appropriate given differing volatility of asset classes
- ❑ **Returns to diversified portfolio cannot be explained by typical risk factors**

Source: Analytic Investors. As described in Harindra de Silva, Greg McMurran and Megan Miller., 2017, "Diversification and the Volatility Risk Premium" chapter in *Risk-Based and Factor Investing* (September 2018).