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The influence of Bitcoin on portfolio diversification and design

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ABSTRACT

We employ a VARMA DCC-GARCH model to search for portfolio diversification with Bitcoin in global industry portfolios and bond index. We find lower dynamic conditional correlations between Bitcoin and industry portfolios and bond index, allowing an investment in Bitcoin to hedge the risk against industry portfolios and bonds. The most effective hedge in a Bitcoin/industry (bond) portfolio is to short Utilities sector. Results are robust to the use of US industry portfolios and a cryptocurrency index instead of global industry portfolios and Bitcoin, respectively. Our results can help investors make informed decisions with regard to risk management and portfolio analysis.

1. Introduction

Bitcoin has received significant attention from investors, speculators, researchers and regulators. Much literature has focused on key questions, such as whether Bitcoin is a currency or speculative asset (Corbet et al., 2019b), its volatility dynamics (Katsiampa et al., 2019), market inefficiency (Corbet et al., 2019a; Sensoy, 2019), interactions with other assets (Corbet et al., 2018), and the development of derivative products (Akyildirim et al., 2019). In search of portfolio diversification, studies investigate at how Bitcoin is diversified with traditional financial assets and alternative investments (Selmi et al., 2018), global and emerging equity markets (Kajtazi and Moro, 2019) and commodities (Dyhrberg, 2016). However, none has attempted how Bitcoin is diversified with industry portfolios and the bond markets. Our study attempts to fill the void in the literature.

We contribute in two ways. First, we provide the empirical evidence of lower dynamic conditional correlations (DCCs) between Bitcoin and industry portfolios & bond index. Second, we find that the most effective hedge in a Bitcoin/industry (bond) portfolio is to short Utilities sector. The paper develops as follows: Section 2 describes the data empirical design, while Section 3 discusses the results of the volatility analyses, the estimate of optimal portfolio design and the associated hedging ratios. Sections 4 concludes.

2. Data and methodology

Our sample period covers from 19 August 2011 to 30 November 2018 and includes daily data of Bitcoin, 11 industry sectors, and

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Table 1
Descriptive statistics.

	Bitcoin	Global Mkts.	Basic Mat.	Cons. Goods	Cons. Serv.	Div. REITs	Health Care
Mean	0.0031	0.0003	0.0000	0.0003	0.0004	0.0003	0.0005
Std. Dev.	0.0601	0.0073	0.0100	0.0067	0.0070	0.0080	0.0073
Skewness	−0.9996	−0.4944	−0.2321	−0.5459	−0.5031	−0.4683	−0.4148
Kurtosis	22.85	7.94	6.91	7.36	6.43	6.6	5.41
Jarque−Bera	7241***	534***	1226***	1602***	1012***	1094***	515***
Q (10)	27***	99***	121***	89***	74***	49***	55***
ADF	−45***	−36***	−34***	−36***	−37***	−39***	−38***
(Pearson) Correlation with Bitcoin	1.0000	0.0324	0.0629	0.0189	0.0246	0.0411	0.0206
	Industrials	Oil & Gas	Technology	Telecoms	Utilities	Financials	PIMCO Bond Index
Mean	0.0004	0.0001	0.0006	0.0002	0.0002	0.0003	0.0001
Std. Dev.	0.0077	0.0107	0.0088	0.0065	0.0068	0.0083	0.0027
Skewness	−0.3905	−0.2	−0.3492	−0.391	−0.4438	−0.5183	−0.2524
Kurtosis	7.45	6.04	5.46	6.59	6.89	9.23	4.6499
Jarque−Bera	1616***	745***	517***	1069***	1258***	3162***	235.81***
Q (10)	118***	68***	62***	62***	50***	96***	24**
ADF	−35***	−37***	−38***	−37***	−39***	−36***	−46***
(Pearson) Correlation with Bitcoin	0.0264	0.0322	0.0343	0.0094	0.0088	0.0283	0.0147

Note: *, **, and *** represent significant at the 0.10, 0.05, and 0.01 levels, respectively.

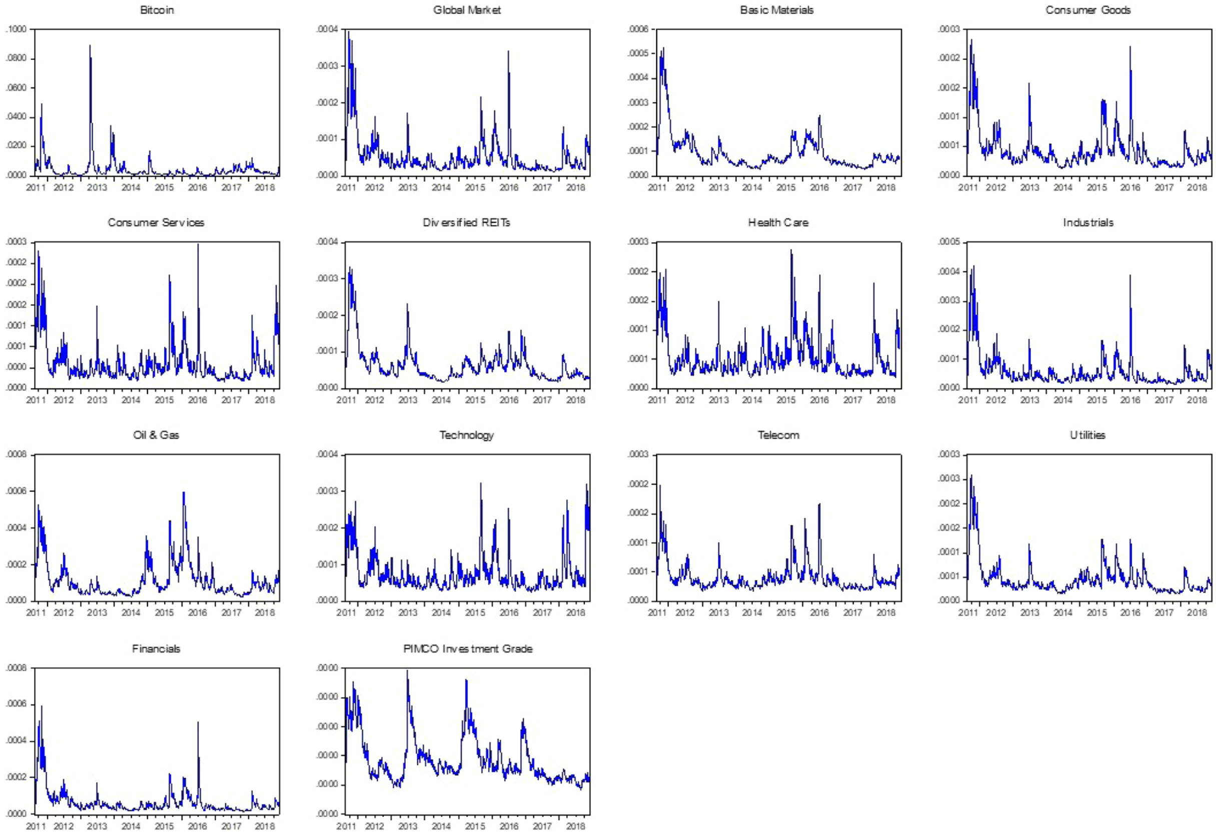

Fig. 1. Return volatility.

the global market sourced from DataStream. Additionally, we use the PIMCO Investment-Grade Corporate Bonds Index to include fixed income - Bitcoin portfolio analysis (Fang et al., 2019). We choose the Bitcoin price from Bitsamp Exchange, because it is one of most popular, liquid and considered a safe exchange by market participants (Urquhart and Zhang, 2019). We choose the sample beginning in 2011, because in earlier periods the liquidity was low and Bitcoin price level and volatility were small (Kajtazi and Moro, 2019).

Both mean return and volatility of Bitcoin are much higher than those of industry portfolios and PIMCO bond index (Table 1 and Fig. 1). The Jarque–Bera test, Ljung–Box statistic, and Augmented Dickey–Fuller test provide evidence of non-normality,

Table 2
VARMA (1,1) GARCH Parameters and diagnostics.

Sector	Conditional Mean Equation			Conditional Variance Equation			Q(10)	Q^2(10)
	Constant (M)	AR (1)	MA (1)	Constant (V)	ARCH	GARCH		
Bitcoin	0.0017	0.9879***	-0.9863***	$0.57x10^{4}$*	0.0154***	0.8505***	77.27***	4.27
Global Market	0.0005***	0.1411	0.0359	$1.06x10^{6}$**	0.1061***	0.8730***	4.95	4.8
Basic Materials	0.0002	0.1629	0.0631	$0.59x10^{6}$*	0.0442***	0.9491***	10.19	6.64
Consumer Goods	0.0005***	0.1835**	-0.017	$0.74x10^{6}$*	0.0720***	0.9115***	4.34	4.47
Consumer Services	0.0006***	0.0423	0.0965	$1.43x10^{6}$***	0.1087***	0.8637***	3.30	8.29
Diversified REITs	0.0033**	0.0787	0.0143	$0.48x10^{6}$*	0.0566***	0.9362***	9.62	9.27
Health Care	0.0007***	0.0487	0.0483	$1.78x10^{6}$*	0.0975***	0.8693***	9.53	9.18
Industrials	0.0006***	0.2166**	-0.126	$1.52x10^{6}$**	0.1066***	0.8671***	4.77	5.22
Oil and Gas	0.0003	0.1803	-0.0344	$0.01x10^{4}$**	0.0754***	0.9174***	3.73	1.94
Technology	0.0009***	0.1035	0.0334	$2.83x10^{6}$***	0.0939***	0.8685***	13.76	3.72
Telecom	0.0002	0.0870	0.0594	$1.03x10^{6}$*	0.0633***	0.9115***	6.91	7.70
Utilities	0.0003**	0.0191	0.0959	$0.64x10^{6}$	0.0620**	09236***	7.70	7.37
Financials	0.0053***	0.167	0.0137	$1.15x10^{6}$**	0.0948***	0.8883***	5.30	2.94
PIMCO Bond Index	0.0001**	−0.0071	−0.0464	0.0775**	0.0343***	0.9547***	12.60	5.65

Note: *, **, and *** represent significant at the 0.10, 0.05, and 0.01 levels, respectively.

autocorrelation, and stationarity in returns, respectively. We employ various specifications of GARCH models to construct the optimum portfolios of Bitcoin, industry portfolios and bond index and chosen VARMA(1,1) DCC-GARCH model as a benchmark model based on information criteria, represented as:

$$r_t = c + \varphi r_{t-1} + \omega \varepsilon_{t-1} + \varepsilon_t \tag{1}$$

$$\varepsilon_t = H_t^{1/2} \eta_t \tag{2}$$

where c is the vector of constant terms. r_t is a $n \times 1$ vector of returns on industry portfolios, bond index or Bitcoin. φ and ω refer to a $n \times 1$ vector of coefficients for AR(1) and MA(1), respectively. ϵ_t is the vector of the error terms. η_t is the sequence of independently and identically distributed random errors, and H_t is the conditional variance-covariance matrix.

In a second-stage analysis, the optimal portfolio design allows investors invest in Bitcoin to hedge against industry portfolios and bond index. Following Kroner and Ng (1998), we determine the optimal weight of Bitcoin in a one-dollar portfolio of industry (or bond index) *i/Bitcoin* at time *t*, denoted by $w_t^{(i/Bitcoin)}$:

$$w_t^{i/Bitcoin} = \frac{h_t^i - h_t^{i/Bitcoin}}{h_t^i - 2h_t^{i/Bitcoin} + h_t^{Bitcoin}} \tag{3}$$

where h_t^i, $h_t^{Bitcoin}$ and $h_t^{(i/Bitcoin)}$ are the conditional volatility of the industry portfolio or bond index, Bitcoin and covariance, respectively at time *t*. However, under the assumption of no short-selling, the portfolio optimisation process imposes the following constraints:

$$w_t^{i/Bitcoin} = \begin{cases} 0 if w_t^{i/Bitcoin} < 0 \\ w_t^{i/Bitcoin} if 0 \leq w_t^{i/Bitcoin} \leq 1 \\ 1 if w_t^{i/Bitcoin} > 1 \end{cases} \tag{4}$$

To minimise the risk of the hedged portfolio, a long position of one-dollar in Bitcoin must be hedged by a short position of $\beta_t^{(i/Bitcoin)}$ dollars in the industry sector, where $\beta_t^{(i/Bitcoin)}$ is the optimal hedge ratio calculated as:

$$\beta_t^{i/Bitcoin} = \frac{h_t^{i/Bitcoin}}{h_t^i} \tag{5}$$

3. Results

3.1. Volatility in Bitcoin, Industry Portfolios and Bond Index

The one-period lagged Bitcoin returns, as measured by the AR(1) coefficient are presented in Table 2, present evidence of a significantly influence on current Bitcoin returns. This largely presents evidence of short-term predictability in Bitcoin price changes. In Table 3, through analysis of the associated GARCH coefficients, we observe the presence of strong volatility persistence of returns.

Table 3
VARMA DCC-GARCH analysis and associated diagnostic tests.

	Global Mkt	Basic Mat.	C. Goods	Serv.	REITs	Health	Industr.	Oil & Gas	Tech	Tel.	Util.	Fin.	Bond Index
Average DCC													
Full Sample	0.0225	0.0395	0.0154	0.0193	0.0104	0.0175	0.0162	0.0165	0.0198	0.0010	0.0043	0.0261	0.0084
Difference in DCC	-9E-06	-4E-03	-5E-03	-5E-06	-3E-11	-1E-02	-6E-03	-9.E-06	-6E-06	-3E-10	-1E-06	-7E-03	3E-04
t-stat difference	−5.44***	−7.53***	−5.06***	−4.62***	−1.98**	−6.86***	−7.05***	−5.65***	−4.78***	−3.05***	−3.48***	−9.95***	0.81
Diagnostic Tests													
LM Test of Tse (2000)	752***	406***	169***	689***	815***	154***	246***	888***	803***	722***	805***	184***	4793***
Hosking Statistics(10)	30.46	30.47	31.74	38.48	36.18	31.73	29.88	20	30.28	43.92	35.66	37.86	23.65
Li and McLeod's (10)	30.46	30.49	31.74	38.47	36.19	31.73	29.88	20.05	30.28	43.89	35.67	37.84	23.68

Notes: The Lagrange multiplier test of Tse, 2000, Hosking, 1980 and Li and McLeod, 1981 checks the null hypothesis of constant correlation, no serial correlation, and no misspecification in the model, respectively. *, **, and *** represent significance at 0.10, 0.05, and 0.01 levels, respectively.

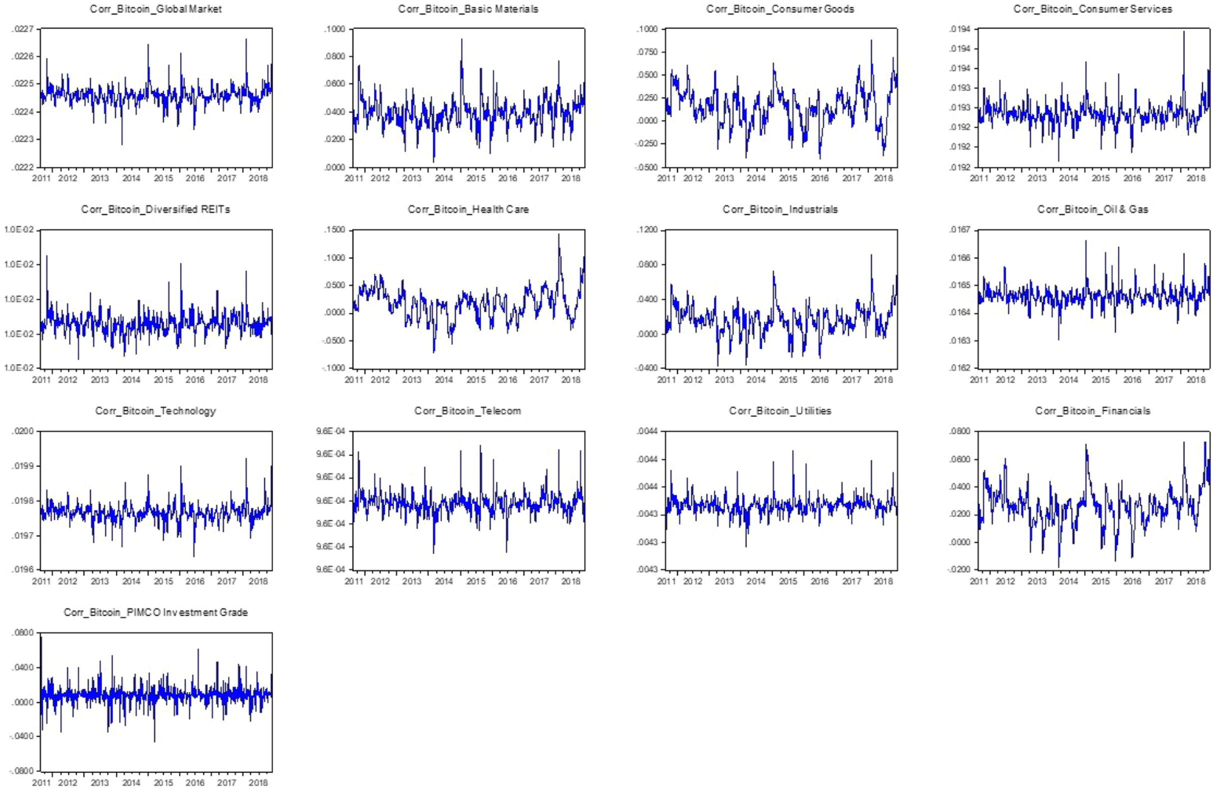

Fig. 2. VARMA DCC-GARCH relationships.

Table 4
Optimal weights and hedge ratios for portfolios.

	Global Mkt	Basic Mat.	C. Goods	Serv.	REITs	Health	Industr.	Oil & Gas	Tech	Tel.	Util.	Fin.	Bond Index
Optimal Weight	0.0255	0.0446	0.0235	0.0254	0.0346	0.0291	0.0290	0.0602	0.0402	0.0242	0.0256	0.0307	0.0043
Optimal Hedge Ratio	0.2026	0.2552	0.1500	0.1717	0.0796	0.1472	0.1358	0.1027	0.1366	0.0462	0.0391	0.2207	0.1775

Hence, investors may consider active investment strategies based on such volatility persistence strength. The results of the Tse (2000) test rejects constant correlations, while our benchmark model passes diagnostic tests as both the Hosking (1980), and the Li and McLeod (1981) tests present no evidence of serial correlation and misspecification in the selected methodology, respectively.

The dynamic correlations between Bitcoin and industry portfolios & bond index appear to be quite low, as presented in Fig. 2, varying from 0.0010 (Telecom) to 0.0395 (Basic Materials). DCCs vary across industries and markets states. As suggested by Cooper et al. (2004), we define the state of the market as Up (Down) when a one-year return is non-negative (negative). DCCs in the down market (n = 597 days) are higher than those in the up market (n = 1,304 days). This result supports the literature that finds lower DCCs in economic downturns (Akhtaruzzaman et al., 2014; Akhtaruzzaman and Shamsuddin, 2016). Lower DCCs and variation in DCCs across industries and bond index provides an opportunity to diversify portfolios.

3.2. Optimal portfolio design and hedging ratios

Results presented in Table 4 and both Figs. 3 and 4, demonstrate that in order to minimise the risk without lowering the expected return, investors should seek reduced exposure to Bitcoin. The estimated optimal weights are found to vary between 0.0043 (bond index) and 0.0602 (oil & gas). The values of optimal hedge ratios are low, indicating that the potential for the opening of a highly effective hedge in the considered industry sectors and PIMCO bond index. For example, if we consider the hedging effectiveness for a

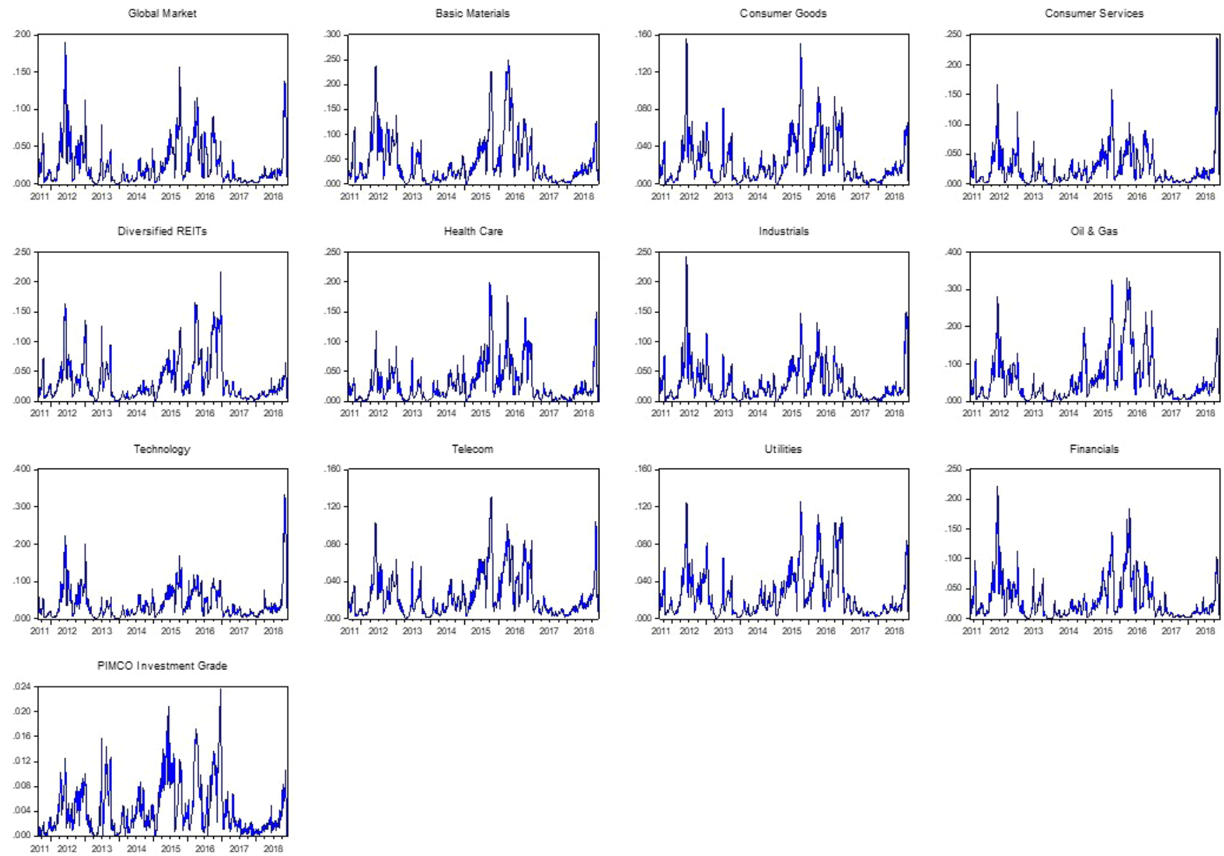

Fig. 3. Optimal weights.

Bitcoin and basic materials portfolio, a hedge ratio of 0.2552 implies that one-dollar long in Bitcoin should be shorted by 25.52 cents in basic materials.

The optimal hedge ratios vary significantly across sectors and the bond index. Among all of the examined pairs, we find that the most effective strategy to hedge the Bitcoin risk exposure is to short the utilities sector which possesses the lowest optimal hedge ratio. In an examination of methodological robustness, we utilise United States industry portfolios and a cryptocurrency index to examine robustness and identify similar results.[1] These results suggest that Bitcoin can be a part of a diversified portfolio which increases the risk-adjusted performance.

Moreover, to check the robustness of the portfolio performance, we have presented the simulated portfolio returns and volatilities generated from optimal weights against individual industries and bond index in Fig. 5. We find that all industry portfolios with Bitcoin have higher return and lower volatility than those of individual industries. However, the bond index portfolio with Bitcoin has higher return, but higher volatility than that of bond index only.

4. Conclusions

We analyse the performance of portfolio diversification through the addition of Bitcoin to global industry portfolios and PIMCO investment grade bond index. Results demonstrate lower dynamic correlations and substantial variation in relationships across industries and the bond index. Further, dynamic correlations are found to be substantially reduced during times of downturn. Results demonstrate that investment in Bitcoin provides an efficient hedging mechanism for a broad number of industrial sectors and bonds, with results found to be robust through the use of a cryptocurrency index and US industry portfolios. Our results help to inform investor decision-making when adding cryptocurrencies as part of the risk management and portfolio analysis process. Given the rise of cryptocurrencies as a currency or speculative investment, future research is warranted on whether it can be used to support diversification practices with financial assets across frontier, emerging and advanced economies in the context of future crypto-currency regulation.

[1] For brevity, these results have been excluded but are available from the authors upon request.

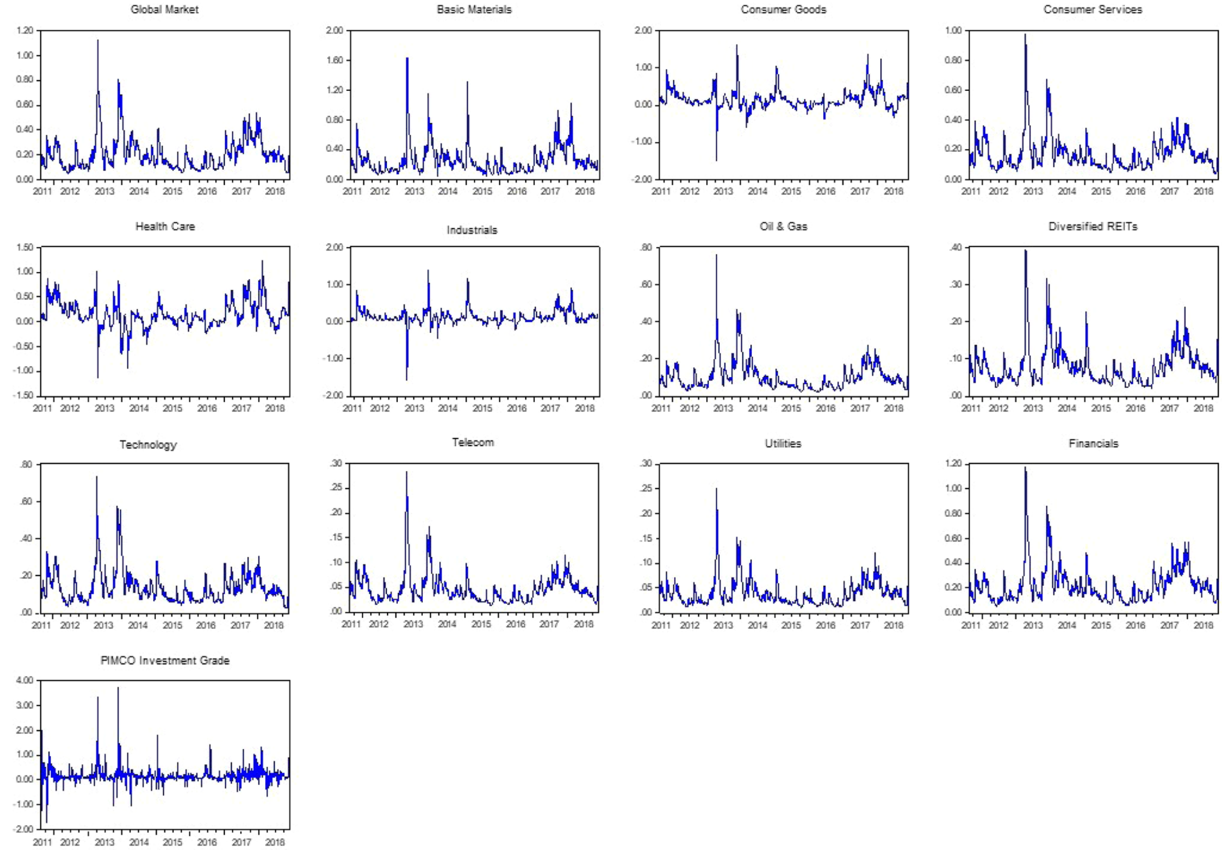

Fig. 4. Optimal hedge ratios.

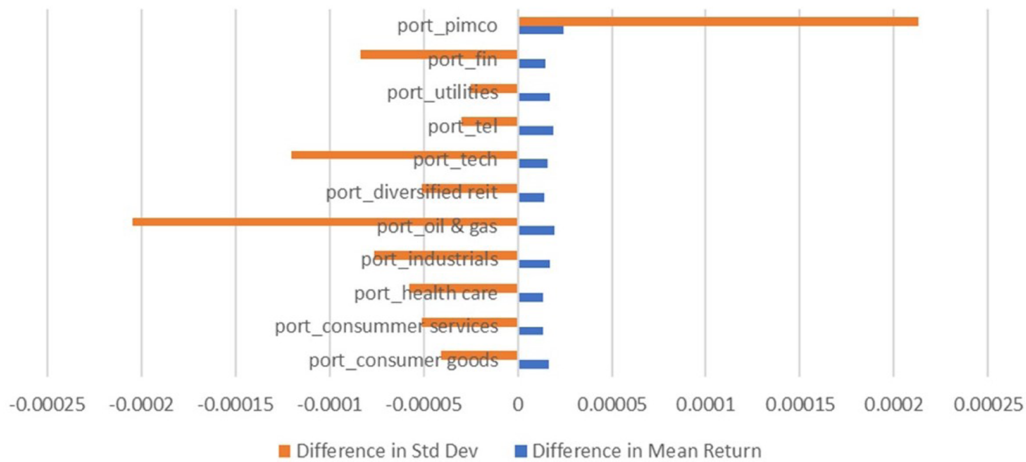

Fig. 5. Individual Sectors vs Simulated Portfolios.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at 10.1016/j.frl.2019.101344

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