Table 1: Determinants of Bitcoin returns

|  |  |  |
| --- | --- | --- |
| **Variable** | **Definition and Source** | **Explanation and Data Source** |
| **Panel A: Bitcoin Market Characteristics Predictors** |
| *BA* | Bid-ask spread measure | Corwin and Schultz (2012),$BA=\frac{2(e^{K}-1)}{1+e^{K}}$ where $K=\frac{\sqrt{2τ}-\sqrt{τ}}{3-2\sqrt{2}}-\sqrt{\frac{γ}{3-2\sqrt{2}}}$ , $τ=\left\{\sum\_{j=0}^{1}\left[ln⁡(\frac{H\_{t+j}^{O}}{L\_{t+j}^{O}})\right]^{2}\right\}$ , $γ=\left[ln⁡(\frac{H\_{t+j}^{O}}{L\_{t+j}^{O}})\right]^{2}$ , where $H\_{t}^{O}$ ($L\_{t}^{O}$) is the observed high (low) Bitcoin price for day t, and $H\_{t+j}^{O}$ ($L\_{t+j}^{O}$) is the observed high (low) Bitcoin price over two days *t* and *t + 1*. We estimate the innovation ($u\_{t}$) BA as the residual of the following AR(2) model (using innovation, , is due to the persistency of liquidity, e.g., Pástor and Stambaugh 2003) $liq\_{t}=α\_{0}+α\_{1}liq\_{t-1}+α\_{2}liq\_{t-2}+u\_{t}$, where $liq\_{t}$ is the liquidity measure of BA in day t. |
| *BD* | Crash dummy | This dummy variable accounts for the crash behaviour of Bitcoin price. This variable takes a value of 1 if on that day there is a price crash and 0 otherwise. The crash date is identified using Investoo.com(https://www.techstars.com/content/startup-digest/history-major-bitcoin-crashes/) |
| *BETA* | Systematic risk | Coefficient from regressing daily excess Bitcoin return on the excess market return (*MKTRF*) over the prior 12 days. |
| *DV* | Dollar volume measure of Bitcoin | Daily dollar volume in Bitcoin market averaged over the prior 12 days (Brennan et al., 1998). We estimate the innovation ($u\_{t}$) DV as the residual of the following AR(2) model (using innovation, , is due to the persistency of liquidity, e.g., Pástor and Stambaugh 2003)$ liq\_{t}=α\_{0}+α\_{1}liq\_{t-1}+α\_{2}liq\_{t-2}+u\_{t}$, where $liq\_{t}$ is the liquidity measure of DV in day t. |
| *ISK* | Idiosyncratic skewness  | Skewness of residuals from regressing daily excess Bitcoin return on the Fama-French three-factor model over the prior 12 days.  |
| *IVOL* | Idiosyncratic volatility | Standard deviation of residuals from regressing daily excess Bitcoin return on the Fama-French three-factor model over the prior 12 days. |
| *RV* | Price impact measure | Daily absolute-return-to-dollar-volume ratio averaged over the prior 12 days, We estimate the innovation () RV as the residual of the following AR (2) model (using innovation, $u\_{t}$, is due to the persistency of liquidity, e.g., Pástor and Stambaugh 2003).$ liq\_{t}=α\_{0}+α\_{1}liq\_{t-1}+α\_{2}liq\_{t-2}+u\_{t}$, where $liq\_{t}$ is the liquidity measure of RV in day t. |
|  |  |  |
| *SK* | Skewness of return | Skewness of daily Bitcoin return over the prior 12 days. |
| *TEUSD* | Transaction fees paid to miners | The total value of all transaction fees paid to miners (Easley et al., 2019). We obtain transaction fee data from https://www.blockchain.com. We estimate the innovation ($u\_{t}$) TEUSE as the residual of the following AR(2) model (using innovation, , is due to the persistency of TEUSE) $TEUSE\_{t}=α\_{0}+α\_{1}TEUSE\_{t-1}+α\_{2}TEUSE\_{t-2}+u\_{t}$, where $TEUSE\_{t}$ is the transaction fees measure of TEUSE in day t. |
| *TSM* | Time-series Momentum | Compound daily excess Bitcoin return over the prior 12 days (Moskowitz et al., 2012). |
| *TSMSV* | Scaled *TSM* by volatility | *TSM* scaled by *VOL* (Moskowitz et al., 2012). |
| *VOL* | Volatility of return | Standard deviation of daily Bitcoin returns over the prior 12 days. |
| *VOLG* | Volatility of return from GARCH (1,1) | Volatility of Bitcoin return estimated from GARCH (1,1) (Cheah et al., 2018). |
| **Panel B: Stock Market Predictors** |
| *CMA* | Investment factor | Kenneth French’s website. |
| *HML* | Book-to-market factor | Kenneth French’s website. |
| *MKTRF* | Daily excess market returns | Kenneth French’s website. |
| *RMW* | Profitability factor | Kenneth French’s website. |
| *SMB* | Size factor | Kenneth French’s website. |
| *UMD* | Momentum factor | Kenneth French’s website. |
| **Panel C: Bond Market Predictors** |
| *JUNK* | The junk spread | Defined as the spread between Moody’s Baa and Aaa corporate bond yields as in Keim and Stambaugh (1986). |
| *RF* | Treasury bill rate | Kenneth French’s website. |
| *TERM* | The term spread | Defined as the spread of the ten-year and a one-year Treasury bond yield as in Fama and French (1989). |
| **Panel D: Sentiment Predictors** |
| BBS | US Investor Sentiment Bull-Bear Spread | AAII Investor Sentiment Survey.  |
| GSI | Google Trend Search Index for Bitcoin | Google Trends for the keyword “Bitcoin” (https://trends.google.com/trends/explore?q=bitcoin&geo=US). |
| TMAX  | The daily high temperature recorded at the Central Park weather station in New York  | Following Novy-Marx (2014) we obtain the weather data from The National Climatic Data Center (NCDC). |
| **Panel E: External Uncertainty Predictors** |
| PU | Economic Policy Uncertainty Index | Economic policy uncertainty website, <http://www.policyuncertainty.com/> (Baker et al.,2016). |
| FU | Financial Uncertainty | Following Jurado et al. (2015), we obtain the data from Sydney Ludvigson’s website.  |
| MU | Macro Uncertainty | Following Jurado et al. (2015), we obtain the data from Sydney Ludvigson’s website.  |
| RU | Real Uncertainty | Following Jurado et al. (2015), we obtain the data from Sydney Ludvigson’s website.  |
| VIX | CBOE S&P500 Volatility Index | Wharton Research Data Services. |
| VXD | CBOE DJIA Volatility Index | Wharton Research Data Services. |
| VXN | CBOE NASDAQ Volatility Index | Wharton Research Data Services. |
| VXO | CBOE S&P100 Volatility Index | Wharton Research Data Services. |

Table 2: Summary Statistics

This table reports descriptive statistics for the key variables. Detailed variable definitions are available in Table 1.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Mean** | **Standard Deviation** | **Minimum** | **Median** | **Maximum** |
| *Return(%)* | 0.38 | 4.69 | -48.52 | 0.22 | 40.14 |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | -0.01  | 1.14  | -14.79  | -0.08  | 16.26  |
| *BD* | 0.19  | 0.40  | 0.00  | 0.00  | 1.00  |
| *BETA* | -0.18  | 3.18  | -19.72  | -0.12  | 35.73  |
| *DV* | 0.00  | 2.78  | -47.85  | -0.08  | 42.42  |
| *ISK* | 0.03  | 0.70  | -2.75  | 0.05  | 2.08  |
| *IVOL* | 0.03  | 0.02  | 0.00  | 0.03  | 0.19  |
| *RV* | 0.00  | 0.00  | -0.01  | 0.00  | 0.01  |
| *SK* | 0.00  | 0.87  | -2.91  | -0.02  | 2.70  |
| *TEUSD* | 0.08  | 27.81  | -348.86  | -1.13  | 482.47  |
| *TSM* | 0.05  | 0.20  | -0.50  | 0.02  | 1.59  |
| *TSMSV* | 1.51  | 4.44  | -9.66  | 0.71  | 22.31  |
| *VOL* | 0.04  | 0.03  | 0.00  | 0.03  | 0.26  |
| *VOLG* | 0.00  | 0.01  | 0.00  | 0.00  | 0.10  |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | 0.00  | 0.31  | -1.32  | 0.00  | 1.97  |
| *HML* | -0.01  | 0.47  | -1.69  | -0.03  | 2.38  |
| *MKTRF* | 0.05  | 0.84  | -4.03  | 0.07  | 5.06  |
| *RMW* | 0.00  | 0.31  | -1.58  | -0.01  | 1.63  |
| *SMB* | 0.01  | 0.48  | -1.63  | 0.00  | 2.52  |
| *UMD* | 0.00  | 0.67  | -3.13  | 0.04  | 3.64  |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | 0.94  | 0.25  | 0.53  | 0.90  | 1.54  |
| *RF* | 0.00  | 0.00  | 0.00  | 0.00  | 0.01  |
| *TERM* | 1.56  | 0.67  | 0.06  | 1.60  | 2.91  |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | 0.06  | 0.13  | -0.35  | 0.06  | 0.44  |
| *GSI* | 161.58  | 240.65  | 3.04  | 77.26  | 3260.00  |
| *TMAX* | 63.11  | 18.26  | 13.00  | 64.00  | 100.00  |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 98.19  | 57.77  | 3.32  | 84.95  | 586.55  |
| *FU* | 0.81  | 0.09  | 0.68  | 0.79  | 1.16  |
| *MU* | 0.61  | 0.03  | 0.55  | 0.60  | 0.69  |
| *RU* | 0.61  | 0.02  | 0.59  | 0.61  | 0.66  |
| *VIX* | 15.30  | 4.14  | 9.14  | 14.26  | 40.74  |
| *VXD* | 14.78  | 3.67  | 7.58  | 13.88  | 34.51  |
| *VXN* | 17.54  | 4.32  | 10.31  | 16.48  | 42.95  |
| *VXO* | 14.76  | 4.61  | 6.32  | 13.83  | 37.66  |
|  |  |  |  |  |  |
| *PCA* | -0.03  | 2.32  | -4.25  | -0.39  | 10.60  |

Table 3: In-sample Predictive Regression Estimation Results

The table reports the ordinary least squares estimate of  and  statistic for the predictive regression model: $RET\_{t,t+h}=α+βx\_{t}+ε\_{t,t+h}$, where $RET\_{t,t+h}=({1}/{h})( RET\_{t+1}+…+ RET\_{t+h})$, $RET\_{t}$ is the Bitcoin log excess return (%) for day t, and $x\_{t}$ is a predictor variable. See Table 1 for the variable definitions of 33 predictors and their principal component. ∗, ∗∗, and ∗∗∗ indicate significance at the 10%, 5%, and 1% levels, respectively, based on one sided wild bootstrapped *p*-value. In order to provide comparable results, we standardize each predictor so the standard deviation is one for all predictors. We also take all the negative of *BD, BETA, ISK, TEUSD, CMA, HML, SMB, RF, BBS, GSI, FU, MU, RU, VIX, VXD, VXN* and *VXO* to facilitate comparisons across predictors.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *h* = 7 days | *h* = 14 days | *h* = 21 days | *h* = 28 days |
|  | $$\hat{β}$$ | *t*-stat | *R*2 (%) | $$\hat{β}$$ | *t*-stat | *R*2 (%) | $$\hat{β}$$ | *t-*stat | *R*2 (%) | $$\hat{β}$$ | *t*-stat | *R*2 (%) |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | 0.12 | 2.12∗∗ | 0.44 | 0.08 | 2.26∗∗∗ | 0.33 | 0.04 | 1.94∗ | 0.13 | 0.05 | 2.16∗∗ | 0.22 |
| *BD* | 0.27 | 4.03∗∗∗ | 2.16 | 0.22 | 3.64∗∗∗ | 2.86 | 0.21 | 3.72∗∗∗ | 3.5 | 0.19 | 3.33∗∗∗ | 3.5 |
| *BETA* | 0.11 | 1.33 | 0.38 | 0.07 | 0.93 | 0.25 | 0.01 | 0.18 | 0.01 | 0 | 0.02 | 0 |
| *DV* | 0.06 | 1.24 | 0.11 | 0.04 | 1.55 | 0.11 | 0.02 | 0.98 | 0.03 | 0.02 | 0.92 | 0.03 |
| *ISK* | 0.03 | 0.4 | 0.03 | 0.03 | 0.48 | 0.05 | 0.08 | 1.43 | 0.52 | 0.1 | 1.93∗ | 0.94 |
| *IVOL* | 0.13 | 1.17 | 0.53 | 0.05 | 0.59 | 0.12 | 0.01 | 0.2 | 0.01 | 0.01 | 0.19 | 0.01 |
| *RV* | 0.06 | 2.47∗ | 0.11 | 0.01 | 0.84 | 0.01 | 0.03 | 1.58 | 0.06 | 0 | 0.4 | 0 |
| *SK* | 0.07 | 1.12 | 0.14 | 0.11 | 2.1∗ | 0.68 | 0.08 | 1.56 | 0.54 | 0.05 | 0.96 | 0.24 |
| *TEUSD* | 0.05 | 1.47 | 0.07 | 0.02 | 0.92 | 0.03 | 0.01 | 0.37 | 0.01 | 0.01 | 0.47 | 0.01 |
| *TSM* | 0.21 | 1.11 | 1.4 | 0.25 | 1.82 | 3.61 | 0.18 | 1.61 | 2.62 | 0.14 | 1.41 | 1.96 |
| *TSMSV* | 0.32 | 2.53∗∗ | 3.2 | 0.34 | 3.37∗∗∗ | 6.82 | 0.3 | 3.29∗∗∗ | 6.93 | 0.26 | 2.92∗∗∗ | 6.44 |
| *VOL* | 0.14 | 1.25 | 0.57 | 0.06 | 0.78 | 0.19 | 0.02 | 0.35 | 0.04 | 0.01 | 0.09 | 0 |
| *VOLG* | 0.22 | 1.96 | 1.43 | 0.09 | 1.12 | 0.45 | 0.05 | 1.13 | 0.22 | 0.04 | 0.97 | 0.13 |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | 0.04 | 0.9 | 0.04 | 0.03 | 0.85 | 0.04 | 0.02 | 0.74 | 0.03 | 0.02 | 0.65 | 0.03 |
| *HML* | 0.06 | 1.49 | 0.11 | 0.02 | 0.7 | 0.02 | 0.02 | 0.8 | 0.03 | 0.02 | 0.96 | 0.04 |
| *MKTRF* | 0.06 | 1.53 | 0.12 | 0.05 | 1.54 | 0.14 | 0.05 | 1.96∗ | 0.19 | 0.05 | 2.01∗ | 0.24 |
| *RMW* | 0.06 | 1.31 | 0.09 | 0.04 | 1.35 | 0.1 | 0.05 | 1.77∗ | 0.18 | 0.05 | 1.85∗ | 0.25 |
| *SMB* | 0.08 | 1.77∗ | 0.2 | 0.02 | 0.61 | 0.02 | 0.02 | 0.77 | 0.04 | 0.01 | 0.5 | 0.01 |
| *UMD* | 0.06 | 1.44 | 0.11 | 0.03 | 1.02 | 0.05 | 0.03 | 1.28 | 0.06 | 0.02 | 0.74 | 0.02 |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | 0.01 | 0.08 | 0 | 0.01 | 0.18 | 0.01 | 0.01 | 0.13 | 0.01 | 0.01 | 0.1 | 0.01 |
| *RF* | 0.15 | 1.96∗ | 0.65 | 0.14 | 1.84 | 1.15 | 0.15 | 1.84 | 1.62 | 0.15 | 1.82 | 1.96 |
| *TERM* | 0.09 | 1.02 | 0.25 | 0.09 | 0.96 | 0.5 | 0.09 | 0.92 | 0.67 | 0.09 | 0.88 | 0.77 |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | 0.07 | 0.94 | 0.17 | 0.05 | 0.57 | 0.12 | 0.04 | 0.52 | 0.16 | 0.05 | 0.58 | 0.24 |
| *GSI* | 0.06 | 0.62 | 0.11 | 0.1 | 1.21 | 0.56 | 0.13 | 1.76 | 1.42 | 0.13 | 1.82 | 1.79 |
| *TMAX* | 0.01 | 0.17 | 0 | 0.01 | 0.15 | 0.01 | 0 | 0.01 | 0 | 0 | 0.02 | 0 |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 0.17 | 2.98∗∗∗ | 0.88 | 0.18 | 3.38∗∗∗ | 1.79 | 0.19 | 3.63∗∗∗ | 2.94 | 0.21 | 3.56∗∗∗ | 4.33 |
| *FU* | 0.26 | 3.48∗∗∗ | 2.01 | 0.25 | 3.21∗∗∗ | 3.44 | 0.25 | 2.96∗∗ | 4.39 | 0.25 | 3.01∗∗ | 5.35 |
| *MU* | 0.03 | 0.49 | 0.04 | 0.03 | 0.47 | 0.07 | 0.03 | 0.39 | 0.08 | 0.03 | 0.31 | 0.06 |
| *RU* | 0.08 | 1.13 | 0.18 | 0.08 | 1.31 | 0.39 | 0.08 | 1.26 | 0.48 | 0.07 | 1.14 | 0.5 |
| *VIX* | 0.14 | 1.92∗ | 0.6 | 0.12 | 1.67 | 0.81 | 0.09 | 1.29 | 0.7 | 0.08 | 1.18 | 0.66 |
| *VXD* | 0.18 | 2.4∗∗ | 0.96 | 0.15 | 2.2∗ | 1.39 | 0.13 | 1.8 | 1.37 | 0.12 | 1.65 | 1.33 |
| *VXN* | 0.21 | 2.86∗∗∗ | 1.32 | 0.18 | 2.5∗∗ | 1.9 | 0.15 | 1.94 | 1.7 | 0.13 | 1.69 | 1.53 |
| *VXO* | 0.16 | 2.3∗∗ | 0.77 | 0.12 | 1.79 | 0.89 | 0.1 | 1.36 | 0.81 | 0.09 | 1.21 | 0.76 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| *PCA* | 0.18 | 2.22∗∗ | 1 | 0.16 | 1.95 | 1.41 | 0.13 | 1.54 | 1.26 | 0.11 | 1.35 | 1.14 |

Table 4: Out-of-Sample Test Results

The table reports the proportional reduction in mean squared forecast error (MSFE) at the *h*-day horizon for a predictive regression forecast of the Bitcoin log excess return based on the predictor variable in the first column vis- a´-vis the prevailing mean benchmark forecast, where statistical significance is based on the Clark and West (2007) statistic for testing the null hypothesis that the prevailing mean MSFE is less than or equal to the predictive regression MSFE, against the alternative hypothesis that the prevailing mean MSFE is greater than the predictive regression MSFE. See Table 1 for the variable definitions of 33 predictors and their principal component. ∗, ∗∗, and ∗∗∗ indicate significance at the 10%, 5%, and 1% levels, respectively.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | *h* = 7 days |  | *h* = 14 days |  | *h* = 21 days |  | *h* = 28 days |
|  |

|  |
| --- |
| $R\_{OS}^{2}$ (%) |

 | *CW*-stat |  |

|  |
| --- |
| $R\_{OS}^{2}$ (%) |

 | *CW*-stat |  |

|  |
| --- |
| $R\_{OS}^{2}$ (%) |

 | *CW*-stat |  |

|  |
| --- |
| $R\_{OS}^{2}$ (%) |

 | *CW*-stat |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | 0.23 | 2.94 ∗∗∗ |  | -0.34 | 1.12 |  | -0.39 | -0.60 |  | -0.15 | 0.73 |
| *BD* | 0.49 | 2.49 ∗∗∗ |  | 0.15 | 2.11 ∗∗\* |  | -1.80 | 1.72∗∗ |  | -3.18 | 1.42∗ |
| *BETA* | 0.07 | 0.93 |  | -0.35 | -0.53 |  | -2.30 | -2.11 |  | -2.42 | -1.72 |
| *DV* | -0.87 | 0.51 |  | -0.34 | 0.56 |  | -1.31 | -0.31 |  | -1.11 | -0.36 |
| *ISK* | -0.71 | -0.42 |  | -0.55 | -2.28 |  | -0.20 | 0.61 |  | -0.18 | 1.38 |
| *IVOL* | 0.52 | 1.38 |  | -0.33 | -0.49 |  | -2.13 | -3.39 |  | -3.34 | -2.95 |
| *RV* | 0.10 | 2.58 ∗∗∗ |  | -0.18 | -2.78 |  | -0.48 | -3.26 |  | -0.31 | -1.85 |
| *SK* | 0.01 | 0.19 |  | 0.37 | 1.23 |  | 0.08 | 0.62 |  | -0.24 | -0.37 |
| *TEUSD* | 0.07 | 1.24 |  | -0.27 | -0.41 |  | -0.68 | -1.95 |  | -0.62 | -1.27 |
| *TSM* | 0.87 | 1.53 ∗ |  | 2.41 | 2.03 ∗∗\* |  | 2.07 | 1.95 ∗∗ |  | 1.50 | 1.85 ∗∗ |
| *TSMSV* | 1.67 | 2.76 ∗∗∗ |  | 2.56 | 2.93 ∗∗∗ |  | 1.85 | 2.71 ∗∗∗ |  | 1.63 | 2.50 ∗∗∗ |
| *VOL* | 0.47 | 1.41 ∗ |  | -0.09 | 0.16 |  | -1.52 | -2.82 |  | -2.68 | -2.99 |
| *VOLG* | 0.74 | 2.18 ∗∗∗ |  | 0.44 | 1.41 |  | 0.01 | 0.16 |  | -0.16 | -0.51 |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | -0.01 | 0.17 |  | -0.21 | -1.21 |  | -0.57 | -1.95 |  | -0.53 | -1.36 |
| *HML* | -0.28 | 0.03 |  | -0.40 | -1.72 |  | -0.46 | -2.72 |  | -0.55 | -2.08 |
| *MKTRF* | -0.81 | -0.22 |  | -0.82 | 0.20 |  | -1.06 | 0.08 |  | -0.58 | 0.48 |
| *RMW* | 0.13 | 1.09 |  | -0.27 | 0.28 |  | -0.37 | -0.19 |  | -0.69 | 0.23 |
| *SMB* | 0.29 | 1.57∗ |  | -0.28 | -1.24 |  | -0.53 | -2.01 |  | -0.59 | -1.79 |
| *UMD* | -0.26 | 0.15 |  | -0.62 | -1.59 |  | -0.90 | -1.88 |  | -1.24 | -2.54 |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | -0.39 | -0.62 |  | -1.07 | -0.97 |  | -1.92 | -1.51 |  | -2.51 | -1.74 |
| *RF* | -1.72 | 0.12 |  | -4.32 | -0.06 |  | -6.51 | -0.11 |  | -7.74 | -0.03 |
| *TERM* | -0.24 | 0.06 |  | -0.87 | -0.27 |  | -1.67 | -0.46 |  | -2.00 | -0.43 |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | 0.07 | 0.59 |  | -0.64 | -1.60 |  | -1.48 | -2.22 |  | -1.34 | -1.63 |
| *GSI* | -3.90 | -0.09 |  | -8.78 | -0.83 |  | -13.09 | -0.70 |  | -18.18 | -0.79 |
| *TMAX* | -0.46 | 0.05 |  | -1.02 | -0.39 |  | -1.74 | -0.94 |  | -2.02 | -1.15 |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 0.87 | 2.91 ∗∗∗ |  | 0.86 | 2.58 ∗∗∗ |  | 1.63 | 2.71 ∗∗∗ |  | 1.87 | 2.74 ∗∗∗ |
| *FU* | 2.81 | 2.95 ∗∗∗ |  | 4.64 | 2.66 ∗∗∗ |  | 6.20 | 2.40 ∗∗∗ |  | 7.92 | 2.31 ∗∗∗ |
| *MU* | -0.42 | -0.34 |  | -1.10 | -0.60 |  | -2.05 | -0.92 |  | -2.64 | -0.95 |
| *RU* | -0.42 | 0.66 |  | -1.15 | 0.53 |  | -2.03 | 0.34 |  | -2.50 | 0.31 |
| *VIX* | -1.77 | -0.02 |  | -2.64 | -0.31 |  | -2.13 | -0.61 |  | -2.05 | -0.82 |
| *VXD* | -1.11 | 0.88 |  | -1.53 | 0.64 |  | -0.67 | 0.44 |  | -0.25 | 0.31 |
| *VXN* | -0.47 | 1.34 ∗ |  | -0.45 | 1.11 |  | 0.04 | 0.72 |  | -0.24 | 0.33 |
| *VXO* | -1.19 | 0.48 |  | -1.84 | -0.05 |  | -1.56 | -0.39 |  | -1.80 | -0.66 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| *PCA* | -0.18 | 1.12 |  | -0.20 | 0.83 |  | -0.06 | 0.46 |  | -0.32 | 0.15 |

Table 5: Out-of-Sample CER Gains

The table reports the certainty equivalent return (CER) gain (in percent) for a mean-variance investor with relative risk aversion coefficient of five who allocates between Bitcoin and T-bills using a predictive regression excess return forecast based on the predictor variable in the first column relative to the prevailing mean benchmark forecast. See Table 1 for the variable definitions of 33 predictors and their principal component. The weight is constrained to lie between 0 and 1. The forecast horizon and rebalancing frequency coincide and are given by h.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *h = 7 days* | *h = 14 days* | *h = 21 days* | *h = 28 days* |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | 5.45  | -0.48  | -0.14  | 5.54  |
| *BD* | 27.82  | 27.10  | 4.80  | 17.04  |
| *BETA* | 4.11  | -0.67  | 2.36  | -4.48  |
| *DV* | -7.05  | -5.39  | -4.22  | -4.92  |
| *ISK* | -2.74  | -0.24  | 0.94  | -2.08  |
| *IVOL* | 10.76  | 4.48  | -1.91  | -0.44  |
| *RV* | 0.14  | -0.05  | -0.11  | 0.02  |
| *SK* | -0.11  | 5.74  | 1.57  | -0.77  |
|  |  |  |  |  |
| *TEUSD* | -3.20  | -1.24  | -4.34  | -4.27  |
| *TSM* | 9.41  | 9.58  | -3.95  | 0.73  |
| *TSMSV* | 21.06  | 16.84  | 20.15  | 10.51  |
| *VOL* | 13.45  | 5.67  | -2.33  | -0.69  |
| *VOLG* | 12.75  | 2.67  | 1.14  | 0.64  |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | 1.36  | 0.37  | 1.61  | 0.63  |
| *HML* | -1.59  | -0.42  | 0.27  | -0.29  |
| *MKTRF* | 11.30  | 1.50  | -1.44  | -0.21  |
| *RMW* | 1.53  | -0.40  | 3.99  | -2.44  |
| *SMB* | 0.70  | -0.26  | 2.22  | 0.24  |
| *UMD* | 6.84  | 0.68  | -2.35  | -0.78  |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | -1.41  | -2.10  | -4.17  | -2.75  |
| *RF* | 1.76  | -2.46  | -11.05  | 1.53  |
| *TERM* | 5.03  | 8.18  | 10.82  | 5.98  |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | 1.98  | -1.13  | 2.03  | 2.07  |
| *GSI* | -4.84  | -11.61  | -0.97  | 7.43  |
| *TMAX* | 3.33  | 1.77  | 5.41  | 1.11  |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 13.49  | 9.75  | -17.73  | -1.59  |
| *FU* | 24.57  | 9.51  | -3.85  | 8.14  |
| *MU* | 0.84  | -4.20  | -10.78  | -5.63  |
| *RU* | 3.58  | -1.45  | -4.66  | -2.02  |
| *VIX* | 9.91  | 3.65  | -15.76  | -7.83  |
| *VXD* | 16.30  | 2.95  | -9.60  | -1.87  |
| *VXN* | 22.14  | 16.55  | 2.34  | 2.94  |
| *VXO* | 12.06  | 0.01  | -12.82  | -8.60  |
|  |  |  |  |  |
| *PCA* | 19.11  | 6.72  | -4.34  | 0.39  |

Table 6: Out-of-Sample CER Gains including Transaction Fees.

See Table 1 for the variable definitions of 33 predictors and their principal component.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *h = 7 days* | *h = 14 days* | *h = 21 days* | *h = 28 days* |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | 4.84 | -0.80 | -0.39 | 5.28 |
| *BD* | 27.66 | 26.90 | 4.60 | 16.95 |
| *BETA* | 3.41 | -0.87 | 2.19 | -4.66 |
| *DV* | -7.74 | -5.73 | -4.45 | -5.12 |
| *ISK* | -3.22 | -0.43 | 0.70 | -2.35 |
| *IVOL* | 10.25 | 4.26 | -2.07 | -0.60 |
| *RV* | -0.05 | -0.24 | -0.27 | -0.14 |
| *SK* | -0.34 | 5.45 | 1.39 | -0.93 |
| *TEUSD* | -3.54 | -1.44 | -4.49 | -4.43 |
| *TSM* | 7.97 | 8.76 | -4.40 | 0.35 |
| *TSMSL* | 18.91 | 15.70 | 19.27 | 9.89 |
| *VOL* | 12.85 | 5.41 | -2.50 | -0.85 |
| *VOLG* | 12.29 | 2.42 | 0.97 | 0.46 |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | 1.13 | 0.18 | 1.36 | 0.42 |
| *HML* | -2.09 | -0.60 | 0.07 | -0.46 |
| *MKTRF* | 10.34 | 1.08 | -1.64 | -0.38 |
| *RMW* | 1.09 | -0.70 | 3.73 | -2.65 |
| *SMB* | 0.06 | -0.47 | 2.04 | 0.05 |
| *UMD* | 6.27 | 0.47 | -2.52 | -0.95 |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | -1.59 | -2.24 | -4.31 | -2.91 |
| *RF* | 1.39 | -2.74 | -11.27 | 1.31 |
| *TERM* | 4.85 | 7.98 | 10.64 | 5.79 |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | 1.71 | -1.34 | 1.83 | 1.87 |
| *GSI* | -5.14 | -11.90 | -1.26 | 7.21 |
| *TMAX* | 2.97 | 1.51 | 5.23 | 0.91 |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 12.43 | 9.19 | -18.13 | -1.93 |
| *FUH* | 24.33 | 9.29 | -4.09 | 7.92 |
| *MUH* | 0.60 | -4.45 | -10.96 | -5.81 |
| *RUH* | 3.32 | -1.68 | -4.83 | -2.19 |
| *VIX* | 9.23 | 3.25 | -16.05 | -8.04 |
| *VXD* | 15.69 | 2.61 | -9.91 | -2.15 |
| *VXN* | 21.49 | 16.18 | 2.03 | 2.66 |
| *VXO* | 11.46 | -0.32 | -13.11 | -8.81 |
|  |  |  |  |  |
| *PCA* | 18.62 | 6.45 | -4.63 | 0.13 |

Table 7: Out-of-Sample Test Results based on Weighted Least Squares using Ex Ante Variance (WLS-EV)

See Table 1 for the variable definitions of 33 predictors and their principal component.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | *h* = 7 days | *h* = 14 days | *h* = 21 days | *h* = 28 days |
|  | $$R\_{OS}^{2}(\%)$$ | CW-stat | $$R\_{OS}^{2}(\%)$$ | *CW*-stat | $$R\_{OS}^{2}(\%)$$ | *CW*-stat | $$R\_{OS}^{2}(\%)$$ | *CW*-stat |
| *Panel A: Bitcoin Market Characteristics Predictors* |
| *BA* | 0.85  | 3.96 ∗∗∗ | 0.38  | 2.13 ∗∗∗ | 0.03  | 0.65  | -0.10  | 0.36  |
| *BD* | 1.64  | 2.95∗∗∗  | 1.07  | 2.44 ∗∗∗ | -0.79  | 1.93 ∗∗ | -2.90  | 1.55 ∗ |
| *BETA* | 0.58  | 1.99 ∗∗∗ | -0.91  | -0.69  | -2.81  | -1.21  | -2.64  | -1.21  |
| *DV* | -0.20  | 1.25  | 0.03  | 1.35 ∗ | -0.73  | 0.45  | -0.96  | 0.06  |
| *ISK* | 0.36  | 1.46 ∗ | 0.08  | 0.53  | 0.33  | 1.21  | 0.09  | 1.66 ∗ |
| *IVOL* | 0.57  | 2.00 ∗∗∗ | -0.43  | -1.03  | -1.99  | -2.63  | -3.24  | -2.39  |
| *RV* | 0.85  | 3.32∗∗∗  | 0.54  | 2.11 ∗∗∗ | 0.10  | 0.46  | -0.03  | -0.01  |
| *SK* | 0.79  | 2.29 ∗∗∗ | 1.15  | 1.96 ∗∗ | 0.68  | 1.34 ∗ | 0.12  | 0.48  |
| *TEUSD* | 0.86  | 3.51 ∗∗∗ | 0.53  | 2.16 ∗∗∗ | 0.07  | 0.49  | -0.15  | -0.25  |
| *TSM* | 0.37  | 1.73 ∗∗∗ | 2.05  | 2.08 ∗∗∗ | 1.80  | 1.99 ∗∗∗ | 0.74  | 1.79∗ |
| *TSMSV* | 1.25  | 2.98∗∗∗  | 2.81  | 3.07 ∗∗∗ | 2.01  | 2.81 ∗∗∗ | 1.49  | 2.57∗∗∗  |
| *VOL* | 0.60  | 2.10 ∗∗∗ | -0.18  | -0.15  | -1.40  | -2.21  | -2.56  | -2.48  |
| *VOLG* | 0.88  | 3.09 ∗∗∗ | 0.49  | 1.82 ∗∗ | 0.14  | 0.60  | -0.12  | -0.17  |
| *Panel B: Stock Market Predictors* |
| *CMA* | 0.76  | 2.41 ∗∗∗ | 0.51  | 1.67 ∗∗ | 0.19  | 0.92  | -0.13  | 0.13  |
| *HML* | 0.59  | 2.30 ∗∗∗ | 0.33  | 1.36 ∗ | 0.11  | 0.56  | -0.21  | -0.44  |
| *MKTRF* | -0.14  | 1.34 ∗ | -0.20  | 1.31 ∗ | -0.68  | 0.92  | -0.49  | 0.84  |
| *RMW* | 0.94  | 3.29 ∗∗∗ | 0.45  | 2.11 ∗∗∗ | 0.21  | 1.31 ∗ | -0.27  | 0.83  |
| *SMB* | 0.96  | 3.45∗∗∗  | 0.43  | 1.58 ∗ | 0.05  | 0.31  | -0.22  | -0.43  |
| *UMD* | 0.70  | 2.78 ∗∗∗ | 0.29  | 1.19  | -0.13  | -0.01  | -0.81  | -1.43  |
| *Panel C: Bond Market Predictors* |  |  |  |  |  |
| *JUNK* | 0.31  | 1.11  | -0.41  | 0.30  | -1.50  | -0.62  | -2.60  | -1.48  |
| *RF* | -0.76  | 0.62  | -4.06  | 0.08  | -7.91  | -0.16  | -9.52  | -0.07  |
| *TERM* | 0.23  | 0.76  | -0.76  | -0.04  | -2.32  | -0.53  | -2.57  | -0.55  |
| *Panel D: Uncertainty and Sentiment Predictors* |
| *BBS* | 0.59  | 2.11 ∗∗∗ | 0.07  | 0.46  | -0.36  | -0.29  | -0.54  | -0.25  |
| *GSI* | -3.71  | 0.28  | -10.26  | -0.26  | -16.25  | -0.33  | -21.51  | -0.45  |
| *TMAX* | 0.14  | 0.95  | -0.54  | -0.01  | -1.45  | -0.79  | -2.02  | -1.19  |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 1.51  | 3.38 ∗∗∗ | 1.47  | 2.83 ∗∗∗ | 2.17  | 2.83 ∗∗∗ | 2.35  | 2.80 ∗∗∗ |
| *FU* | 3.31  | 3.08 ∗∗∗ | 4.74  | 2.67 ∗∗∗ | 5.99  | 2.42 ∗∗∗ | 7.29  | 2.31 ∗∗∗ |
| *MU* | 0.11  | 0.84  | -0.81  | -0.35  | -2.02  | -0.90  | -2.66  | -0.93  |
| *RU* | 0.38  | 1.75∗∗∗  | -0.32  | 1.11  | -1.59  | 0.72  | -2.33  | 0.52  |
| *VIX* | -0.36  | 0.45  | -1.29  | -0.28  | -1.82  | -0.76  | -2.32  | -1.09  |
| *VXD* | 0.23  | 1.29∗ | -0.25  | 0.76  | -0.42  | 0.42  | -0.60  | 0.13  |
| *VXN* | 0.71  | 1.72 ∗∗ | 0.58  | 1.25  | 0.13  | 0.70  | -0.68  | 0.13  |
| *VXO* | 0.08  | 0.93  | -0.80  | -0.02  | -1.44  | -0.54  | -2.17  | -0.94  |
|  |  |  |  |  |  |  |  |  |
| *PCA* | 0.69  | 1.53 ∗ | 0.34  | 0.87  | -0.19  | 0.33  | -0.85  | -0.11  |

Table 8: Predictive Regressions via the Instrumental Variable (IVX) Approach

The table presents the results of univariate predictive regressions models, as the IVX-Wald refers to the Wald statistic. See Table 1 for the variable definitions of 33 predictors and their principal component.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | *h* = 7 days |  | *h* = 14 days |  | *h* = 21 days |  | *h* = 28 days |
|  | IVX-Wald | *p*-value |  | IVX-Wald | *p*-value |  | IVX-Wald | *p*-value |  | IVX-Wald | *p*-value |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | 10.61 | 0 |  | 8.71 | 0 |  | 4.7 | 0.03 |  | 8.11 | 0 |
| *BD* | 6.63 | 0.01 |  | 4.54 | 0.03 |  | 4.11 | 0.04 |  | 3.33 | 0.07 |
| *BETA* | 2.77 | 0.1 |  | 1.62 | 0.2 |  | 0.4 | 0.53 |  | 0.22 | 0.64 |
| *DV* | 2.84 | 0.09 |  | 3.09 | 0.08 |  | 1.02 | 0.31 |  | 1.24 | 0.27 |
| *ISK* | 0.64 | 0.43 |  | 0.01 | 0.94 |  | 0.58 | 0.45 |  | 1.44 | 0.23 |
| *IVOL* | 1.07 | 0.3 |  | 0.01 | 0.93 |  | 0.09 | 0.77 |  | 0.35 | 0.55 |
| *RV* | 2.6 | 0.11 |  | 0.18 | 0.67 |  | 2.22 | 0.14 |  | 0.05 | 0.83 |
| *SK* | 0.21 | 0.65 |  | 1.33 | 0.25 |  | 0.77 | 0.38 |  | 0.14 | 0.71 |
| *TEUSD* | 3.22 | 0.07 |  | 1.99 | 0.16 |  | 0.44 | 0.51 |  | 0.86 | 0.35 |
| *TSM* | 6.09 | 0.01 |  | 9.21 | 0 |  | 6.07 | 0.01 |  | 4.41 | 0.04 |
| *TSMSV* | 14.1 | 0 |  | 18.63 | 0 |  | 16.36 | 0 |  | 14.1 | 0 |
| *VOL* | 1.46 | 0.23 |  | 0.12 | 0.73 |  | 0.01 | 0.94 |  | 0.17 | 0.68 |
| *VOLG* | 7.08 | 0.01 |  | 1.13 | 0.29 |  | 0.35 | 0.56 |  | 0.13 | 0.72 |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | 0.05 | 0.82 |  | 0 | 0.96 |  | 0.06 | 0.81 |  | 0.11 | 0.74 |
| *HML* | 0.02 | 0.9 |  | 0.8 | 0.37 |  | 0.95 | 0.33 |  | 0.89 | 0.35 |
| *MKTRF* | 2.16 | 0.14 |  | 2.79 | 0.09 |  | 3.94 | 0.05 |  | 5.1 | 0.02 |
| *RMW* | 0.33 | 0.56 |  | 0.15 | 0.7 |  | 0.37 | 0.54 |  | 0.6 | 0.44 |
| *SMB* | 3.44 | 0.06 |  | 0.65 | 0.42 |  | 1.03 | 0.31 |  | 0.64 | 0.42 |
| *UMD* | 0.22 | 0.64 |  | 0.04 | 0.85 |  | 0.06 | 0.8 |  | 0.35 | 0.55 |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | 0.69 | 0.41 |  | 0.59 | 0.44 |  | 0.67 | 0.41 |  | 0.68 | 0.41 |
| *RF* | 2.16 | 0.14 |  | 1.93 | 0.16 |  | 1.95 | 0.16 |  | 1.88 | 0.17 |
| *TERM* | 0.82 | 0.36 |  | 0.86 | 0.35 |  | 0.84 | 0.36 |  | 0.78 | 0.38 |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | 0.47 | 0.49 |  | 0.14 | 0.71 |  | 0.14 | 0.71 |  | 0.22 | 0.64 |
| *GSI* | 0.09 | 0.77 |  | 0.62 | 0.43 |  | 1.54 | 0.21 |  | 1.66 | 0.2 |
| *TMAX* | 0.05 | 0.83 |  | 0.04 | 0.83 |  | 0.01 | 0.93 |  | 0 | 0.95 |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 4.06 | 0.04 |  | 5.25 | 0.02 |  | 7.32 | 0.01 |  | 9.82 | 0 |
| *FU* | 9.3 | 0 |  | 9 | 0 |  | 8.89 | 0 |  | 8.94 | 0 |
| *MU* | 0.69 | 0.41 |  | 0.7 | 0.4 |  | 0.64 | 0.42 |  | 0.53 | 0.47 |
| *RU* | 0.63 | 0.43 |  | 0.71 | 0.4 |  | 0.65 | 0.42 |  | 0.55 | 0.46 |
| *VIX* | 6.34 | 0.01 |  | 5.94 | 0.01 |  | 5.35 | 0.02 |  | 5.17 | 0.02 |
| *VXD* | 6.83 | 0.01 |  | 6.35 | 0.01 |  | 5.77 | 0.02 |  | 5.4 | 0.02 |
| *VXN* | 7.81 | 0.01 |  | 7.04 | 0.01 |  | 5.84 | 0.02 |  | 5.1 | 0.02 |
| *VXO* | 6.84 | 0.01 |  | 5.69 | 0.02 |  | 5.09 | 0.02 |  | 4.78 | 0.03 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| *PCA* | 6.82 | 0.01 |  | 6.08 | 0.01 |  | 5.07 | 0.02 |  | 4.47 | 0.03 |

Table 9: Predictive Regression Structural Stability Test.

This table presents the Elliott and Müller (2006) $\hat{qLL}$ statistic for the predictive regression model. The $\hat{qLL}$ statistic is for testing the null hypothesis that the intercept and slope coefficients are constant. The 10%, 5%, and 1% critical values for the $\hat{qLL}$ statistics are -12.80, -14.32, and -17.57, respectively (Elliott and Müller, 2006). See Table 1 for the variable definitions of 33 predictors and their principal component.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | *h* = 7 days |  | *h* = 14 days |  | *h* = 21 days |  | *h* = 28 days |
|  | $\hat{qLL}$ statistics |  | $\hat{qLL}$ statistics |  | $\hat{qLL}$ statistics |  | $\hat{qLL}$ statistics |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | -1.92 |  | -6.23 |  | -5.79 |  | -3.05 |
| *BD* | -5.48 |  | -6.25 |  | -8.76 |  | -10.29 |
| *BETA* | -2.34 |  | -3.73 |  | -4.72 |  | -4.16 |
| *DV* | -1.07 |  | -1.77 |  | -3.22 |  | -1.48 |
| *ISK* | -4.44 |  | -3.09 |  | -3.91 |  | -4.79 |
| *IVOL* | -3.56 |  | -3.42 |  | -2.79 |  | -3.27 |
| *RV* | -0.77 |  | -0.73 |  | -0.75 |  | -1.15 |
| *SK* | -4.13 |  | -3.66 |  | -4.35 |  | -4.3 |
| *TEUSD* | -1.21 |  | -1.55 |  | -1.63 |  | -1.38 |
| *TSM* | -2.25 |  | -1.08 |  | -1.08 |  | -1.28 |
| *TSMSV* | -2.97 |  | -3.71 |  | -4.62 |  | -4.31 |
| *VOL* | -3.73 |  | -3.23 |  | -2.3 |  | -2.8 |
| *VOLG* | -1.57 |  | -0.7 |  | -1.02 |  | -1.43 |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | -2.86 |  | -2.17 |  | -5.95 |  | -6.33 |
| *HML* | -3.01 |  | -2.13 |  | -3.65 |  | -3.75 |
| *MKTRF* | -7.07 |  | -10.66 |  | -11.79 |  | -8.57 |
| *RMW* | -2.27 |  | -3.2 |  | -3.81 |  | -4.82 |
| *SMB* | -4.09 |  | -5.75 |  | -3.91 |  | -2.54 |
| *UMD* | -5.95 |  | -4.37 |  | -4.96 |  | -9.44 |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | -5.23 |  | -5.04 |  | -4.85 |  | -4.83 |
| *RF* | -7.7 |  | -7.81 |  | -7.84 |  | -7.92 |
| *TERM* | -10.29 |  | -8.41 |  | -8 |  | -7.78 |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | -7.05 |  | -7.61 |  | -7.1 |  | -5.5 |
| *GSI* | -4.01 |  | -4.63 |  | -5.01 |  | -4.97 |
| *TMAX* | -11.88 |  | -9.06 |  | -7.89 |  | -7.15 |
| *VIX* | -5.48 |  | -5.49 |  | -5.82 |  | -5.92 |
| *VXD* | -5.98 |  | -5.86 |  | -6.04 |  | -6.47 |
| *VXN* | -6.49 |  | -6.46 |  | -7.06 |  | -7.68 |
| *VXO* | -5.58 |  | -5.5 |  | -6.1 |  | -6.17 |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | -7.65 |  | -9.88 |  | -8.87 |  | -9.89 |
| *FU* | -2.85 |  | -2.67 |  | -2.54 |  | -2.49 |
| *MU* | -5.43 |  | -5.09 |  | -4.86 |  | -4.86 |
| *RU* | -5.94 |  | -7.76 |  | -8.32 |  | -8.66 |
| *VIX* | -5.48 |  | -5.49 |  | -5.82 |  | -5.92 |
| *VXD* | -5.98 |  | -5.86 |  | -6.04 |  | -6.47 |
| *VXN* | -6.49 |  | -6.46 |  | -7.06 |  | -7.68 |
| *VXO* | -5.58 |  | -5.5 |  | -6.1 |  | -6.17 |
|  |  |  |  |  |  |  |  |
| *PCA* | -5.46 |  | -5.46 |  | -5.92 |  | -6.29 |

Table 10: Density Forecast

This table presents the weighted likelihood ratio test statistic of Amisano and Giacomini (2007) for pairwise comparison of the performance of two density

forecasts. ∗, ∗∗, and ∗∗∗ indicate significance at the 10%, 5%, and 1% levels, respectively. See Table 1 for the variable definitions of 33 predictors and their principal component.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | *h* = 7 days |  | *h* = 14 days |  | *h* = 21 days |  | *h* = 28 days |
|  | weighted likelihood ratio | *t*-stat |  | weighted likelihood ratio | *t*-stat |  | weighted likelihood ratio | *t*-stat |  | weighted likelihood ratio | *t*-stat |
| ***Panel A: Bitcoin Market Characteristics Predictors*** |
| *BA* | 0.16 | 1.66∗ |  | 0.04 | 0.38 |  | 0.04 | 0.58 |  | 0.09 | 1.09 |
| *BD* | 0.71 | 2.19∗∗ |  | 0.83 | 2.17∗∗ |  | 0.57 | 1.29 |  | 0.17 | 0.32 |
| *BETA* | 0.08 | 0.58 |  | -0.07 | -0.99 |  | -0.55 | -4.99 |  | -0.62 | -4.72 |
| *DV* | -0.25 | -1.21 |  | -0.03 | -0.2 |  | -0.26 | -1.1 |  | -0.26 | -1.15 |
| *ISK* | -0.19 | -1.99 |  | -0.11 | -4.08 |  | 0.15 | 1.17 |  | 0.26 | 1.3 |
| *IVOL* | 0.23 | 2.04∗∗ |  | -0.04 | -0.77 |  | -0.42 | -12.43 |  | -0.71 | -11.93 |
| *RV* | 0.04 | 16.57∗∗∗ |  | 0 | -5.75 |  | 0 | 0.61 |  | 0 | -12.05 |
| *SK* | 0 | 0.08 |  | 0.28 | 2.33∗∗ |  | 0.21 | 2.27∗∗ |  | 0.04 | 0.8 |
| *TEUSD* | 0.01 | 0.1 |  | -0.04 | -0.36 |  | -0.09 | -0.85 |  | -0.1 | -0.78 |
| *TSM* | 0.57 | 2.56∗∗ |  | 1.6 | 4.43∗∗∗ |  | 1.31 | 4.91∗∗∗ |  | 0.96 | 4.25∗∗∗ |
| *TSMSV* | 1.28 | 3.46∗∗∗ |  | 2.61 | 4.66∗∗∗ |  | 2.55 | 4.68∗∗∗ |  | 2.32 | 4.48∗∗∗ |
| *VOL* | 0.24 | 1.97∗∗ |  | 0.03 | 0.38 |  | -0.28 | -8.31 |  | -0.57 | -13.18 |
| *VOLG* | 0.56 | 6.44∗∗∗ |  | 0.25 | 4.91∗∗∗ |  | 0.14 | 4.46∗∗∗ |  | 0.06 | 2.78∗∗∗ |
| ***Panel B: Stock Market Predictors*** |
| *CMA* | -0.02 | -0.42 |  | -0.02 | -0.49 |  | -0.04 | -1 |  | -0.07 | -1.66 |
| *HML* | -0.04 | -0.54 |  | -0.05 | -1.29 |  | -0.01 | -0.52 |  | -0.05 | -2.07 |
| *MKTRF* | -0.15 | -1.45 |  | -0.11 | -0.96 |  | -0.09 | -0.75 |  | -0.01 | -0.06 |
| *RMW* | 0.03 | 0.43 |  | 0 | -0.03 |  | 0.05 | 0.61 |  | -0.02 | -0.13 |
| *SMB* | 0.1 | 1.12 |  | -0.03 | -0.8 |  | -0.03 | -0.7 |  | -0.07 | -1.75 |
| *UMD* | -0.04 | -0.56 |  | -0.09 | -1.72 |  | -0.09 | -1.51 |  | -0.2 | -3.38 |
| ***Panel C: Bond Market Predictors*** |
| *JUNK* | -0.12 | -2.53 |  | -0.26 | -3.69 |  | -0.42 | -5.52 |  | -0.59 | -7.52 |
| *RF* | -0.54 | -1.71 |  | -1.38 | -2.75 |  | -2.09 | -3.36 |  | -2.65 | -3.53 |
| *TERM* | -0.08 | -0.68 |  | -0.21 | -1.35 |  | -0.38 | -2.08 |  | -0.53 | -2.43 |
| ***Panel D: Sentiment Predictors*** |
| *BBS* | 0.02 | 0.49 |  | -0.14 | -3.37 |  | -0.28 | -5.3 |  | -0.27 | -4.3 |
| *GSI* | -1.26 | -2.5 |  | -2.77 | -4.17 |  | -3.91 | -5.78 |  | -5.65 | -6.85 |
| *TMAX* | -0.14 | -1.52 |  | -0.26 | -2.38 |  | -0.4 | -3.78 |  | -0.51 | -4.82 |
| ***Panel E: Uncertainty Predictors*** |
| *PU* | 0.41 | 2.42∗∗ |  | 0.69 | 2.35∗∗ |  | 1.23 | 3.04∗∗∗ |  | 1.64 | 3.32∗∗∗ |
| *FU* | 1.06 | 2.74∗∗∗ |  | 1.84 | 3.77∗∗∗ |  | 2.46 | 4.73∗∗∗ |  | 3.11 | 5.41∗∗∗ |
| *MU* | -0.11 | -1.75 |  | -0.23 | -2.48 |  | -0.4 | -3.73 |  | -0.58 | -4.77 |
| *RU* | -0.06 | -0.58 |  | -0.15 | -0.96 |  | -0.28 | -1.61 |  | -0.44 | -2.27 |
| *VIX* | -0.24 | -1.15 |  | -0.39 | -1.6 |  | -0.28 | -1.59 |  | -0.33 | -2.28 |
| *VXD* | 0 | -0.01 |  | 0.04 | 0.15 |  | 0.26 | 1.33 |  | 0.29 | 1.82∗ |
| *VXN* | 0.24 | 1.02 |  | 0.42 | 1.63 |  | 0.5 | 2.69∗∗∗ |  | 0.33 | 2.27∗∗ |
| *VXO* | -0.07 | -0.34 |  | -0.19 | -0.86 |  | -0.15 | -0.89 |  | -0.29 | -2.01 |
|  |  |  |  |  |  |  |  |  |  |  |  |
| *PCA* | 0.21 | 1.05 |  | 0.33 | 1.51 |  | 0.32 | 2.06 |  | 0.16 | 1.26 |