

VECMPAPER

#Bitcoin

```
##                ME      RMSE      MAE      MPE      MAPE      MASE
## Training set -0.0002543513 0.1105622 0.08306289 137.5124 170.3833 0.7361292
##                ACF1
## Training set -0.0004880417
```

```
## [1] 0.08035068
```

```
mse <- mean(vecm$residuals[,4]^2)

rmvecm <- sqrt(mse)

rmvecm
```

```
## [1] 0.0734269
```

vecm

```
##                ECT1      ECT2      ECT3 Intercept      waves -1
## Equation waves  0.08600563 -0.2771941 0.17419295 -2.902344 0.04973852
## Equation cardano 0.22057625 -0.4703639 0.23200719 -4.342538 -0.29283398
## Equation eth    0.16551699 -0.2464335 0.03889703 -2.296507 -0.11976238
## Equation btc    0.09805917 -0.1495394 0.05291513 -1.119965 -0.06963228
##                cardano -1      eth -1      btc -1      waves -2 cardano -2
## Equation waves  0.19301029 -0.4349889 0.06640963 -0.1564193 0.3057121
## Equation cardano 0.31020304 -0.2216167 0.09858172 -0.3255958 0.4168542
## Equation eth    0.12219472 -0.1365361 0.02389640 -0.2285748 0.1985553
## Equation btc    0.06499364 -0.1693738 0.12148020 -0.1861183 0.1162780
##                eth -2      btc -2      waves -3 cardano -3      eth -3
## Equation waves  -0.3675931 0.33969706 -0.09973034 0.1719755 -0.5059835
## Equation cardano -0.1375130 -0.13234803 -0.17314360 0.5700657 -0.8548316
## Equation eth    -0.1421997 0.02892106 -0.09491961 0.3246808 -0.4709854
## Equation btc    -0.1005473 0.07542717 -0.01729193 0.1640340 -0.3566401
##                btc -3      waves -4 cardano -4      eth -4      btc -4
## Equation waves  0.07532391 0.11126939 0.01151074 -0.21818775 -0.2648910
## Equation cardano 0.20042239 -0.13337387 0.15665949 -0.17683640 -0.1455958
## Equation eth    0.03296254 -0.03946027 0.02788619 -0.01568576 -0.2098137
## Equation btc    0.12339087 0.04335164 0.09196053 -0.04945227 -0.1340241
##                waves -5 cardano -5      eth -5      btc -5      waves -6
## Equation waves  -0.20765905 0.6441540 -0.3449673 -0.12211875 -0.3017773
## Equation cardano -0.14891373 0.4224994 -0.3237913 -0.09021242 -0.2042145
## Equation eth    -0.07976505 0.4677477 -0.5096914 0.02249707 -0.2212273
## Equation btc    -0.01492827 0.2602281 -0.2342008 -0.04284104 -0.1196523
```

```

##          cardano -6      eth -6      btc -6      waves -7 cardano -7
## Equation waves      0.264442305 -0.190726166 -0.30467545  0.0053370292  0.3171143
## Equation cardano    0.287176488 -0.008214345 -0.56138938 -0.2375154400  0.4486858
## Equation eth        0.015771523  0.072411798 -0.20184611 -0.0006678628  0.1587687
## Equation btc       -0.003091591  0.100363981 -0.06911773 -0.0577307834  0.1012989
##          eth -7      btc -7      waves -8 cardano -8      eth -8
## Equation waves     -0.68557747  0.09680799  0.04444084  0.18509256 -0.7204367
## Equation cardano   -0.20056991 -0.31003161 -0.07603267  0.29056444 -0.6034692
## Equation eth       -0.15886378 -0.16097781  0.01800719  0.24629829 -0.3676721
## Equation btc       -0.04744464 -0.03711704  0.01409523  0.07325299 -0.1913995
##          btc -8      waves -9 cardano -9      eth -9      btc -9
## Equation waves     0.7122180  0.082444548  0.07336162 -0.32544457 -0.08912733
## Equation cardano   0.3363630  0.001000874  0.13310246 -0.68435548  0.47617595
## Equation eth       0.2337321  0.032383222  0.10869588 -0.21908650  0.01710992
## Equation btc       0.2309486  0.002074461  0.04027339 -0.08506864 -0.02761616
##          waves -10 cardano -10      eth -10      btc -10      waves -11
## Equation waves     0.12110539  0.5151688 -0.5981384 -0.22656391 -0.22193633
## Equation cardano   0.04583619  0.2849258 -0.4099248  0.06327877 -0.09493885
## Equation eth       0.05544361  0.1956944 -0.3162440 -0.04782558 -0.10330090
## Equation btc       0.06623348  0.0333722 -0.1484316  0.08382708 -0.04186232
##          cardano -11      eth -11      btc -11      waves -12 cardano -12
## Equation waves     0.57927854  0.08146751 -0.3171318  0.15375632  0.2806795
## Equation cardano   0.62572855 -0.10022508 -0.6104714  0.08886493  0.3406111
## Equation eth       0.34195178 -0.05112033 -0.1430370  0.10839474  0.1726656
## Equation btc       0.04201314  0.25068311 -0.1523958  0.01549504  0.1965605
##          eth -12      btc -12      waves -13 cardano -13      eth -13
## Equation waves     -0.586426105  0.038408672  0.00509963  0.09122907 -0.20276732
## Equation cardano   -0.307027750 -0.111160642 -0.25292231  0.51619038 -0.19877094
## Equation eth       -0.204941423 -0.004943299 -0.14522032  0.33466854  0.05846481
## Equation btc       0.001721742 -0.168241397 -0.09703403  0.24055485  0.04482758
##          btc -13      waves -14 cardano -14      eth -14      btc -14
## Equation waves     -0.01258575 -0.04880773  0.006872494  0.26573370 -0.4594346
## Equation cardano   -0.10294523 -0.01391714  0.112983362 -0.06802449 -0.2087065
## Equation eth       -0.23423856 -0.08671410 -0.022675064  0.25669768 -0.3035171
## Equation btc       -0.21057978 -0.07931666 -0.126651971  0.30187937 -0.1865573
##          waves -15 cardano -15      eth -15      btc -15      waves -16
## Equation waves     0.33077384  0.01755607 -0.31744818 -0.085367674 -0.01671462
## Equation cardano   0.21890010 -0.11889798 -0.20238703 -0.002387948  0.19875114
## Equation eth       0.04644020 -0.01803003  0.04953601 -0.160604991  0.08182715
## Equation btc       0.01493692 -0.06362009  0.02786395 -0.041058663  0.07980877
##          cardano -16      eth -16      btc -16      waves -17 cardano -17
## Equation waves     0.30999466 -0.1634184 -0.03273042 -0.02033369  0.30086098
## Equation cardano   0.11206683  0.2179920 -0.56487070 -0.08219932  0.31793035
## Equation eth       0.10868517  0.1271101 -0.30752112 -0.10640290  0.16482328
## Equation btc       -0.03038566  0.1937122 -0.20058668 -0.01036574  0.09628293
##          eth -17      btc -17      waves -18 cardano -18      eth -18
## Equation waves     0.06388996 -0.22892116  0.145078288  0.02691514 -0.09686454
## Equation cardano   -0.14038928 -0.19318043  0.057431061  0.20022995  0.02355957
## Equation eth       0.01559864  0.01880193 -0.008218902  0.08170086  0.12969907
## Equation btc       -0.04602696  0.02077377 -0.003104484  0.08997315  0.06711550
##          btc -18      waves -19 cardano -19      eth -19      btc -19
## Equation waves     -0.2324111 -0.17481434 -0.002225777  0.07745679  0.0964030050
## Equation cardano   -0.4791112 -0.06713998  0.146939773 -0.26164352 -0.0004532216
## Equation eth       -0.3181191 -0.06024351 -0.036527474 -0.01835055 -0.0422573444

```

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## Equation btc      -0.1962605 -0.06025146 -0.029734825 -0.01756171 -0.0111345081
##                  waves -20 cardano -20   eth -20   btc -20
## Equation waves    -0.093284739  0.19706386  0.1294742 -0.4883297
## Equation cardano -0.122375070  0.10602698  0.1543830 -0.2661426
## Equation eth      -0.008788115  0.07566620  0.2121166 -0.4876700
## Equation btc      0.021501301 -0.02232556  0.1039153 -0.2263247
```

```
toLatex(vecm)
```

```
## %insert in the preamble and uncomment the line you want for usual /medium /small matrix
## %\usepackage{amsmath} \newenvironment{smatrix}{\begin{pmatrix}}{\end{pmatrix}} %USUAL
## %\usepackage{amsmath} \newenvironment{smatrix}{\left(\begin{smallmatrix}}{\end{smallmatrix}\right)} %
## %\usepackage{nccmath} \newenvironment{smatrix}{\left(\begin{mmatrix}}{\end{mmatrix}\right)} %MEDIUM
## \begin{equation}
## \begin{smatrix} %explained vector
## \Delta X_{t-1}^1 \quad \Delta X_{t-1}^2 \quad \Delta X_{t-1}^3 \quad \Delta X_{t-1}^4
## \end{smatrix}=
## +\begin{smatrix} %ECT
## 0.0860 & -0.2772 & 0.1742 \quad \Delta X_{t-1}^1 \\
## 0.2206 & -0.4704 & 0.2320 \quad \Delta X_{t-1}^2 \\
## 0.1655 & -0.2464 & 0.0389 \quad \Delta X_{t-1}^3 \\
## 0.0981 & -0.1495 & 0.0529 \quad \Delta X_{t-1}^4 \\
## \end{smatrix}ECT_{t-1}
## \begin{smatrix} %const
## -2.9023 \quad \Delta X_{t-1}^1 \quad -4.3425 \quad \Delta X_{t-1}^2 \quad -2.2965 \quad \Delta X_{t-1}^3 \quad -1.1200 \quad \Delta X_{t-1}^4
## \end{smatrix}
## +\begin{smatrix} %Lag1
## 0.0497 & 0.1930 & -0.4350 & 0.0664 \quad \Delta X_{t-1}^1 \\
## -0.2928 & 0.3102 & -0.2216 & 0.0986 \quad \Delta X_{t-1}^2 \\
## -0.1198 & 0.1222 & -0.1365 & 0.0239 \quad \Delta X_{t-1}^3 \\
## -0.0696 & 0.0650 & -0.1694 & 0.1215 \quad \Delta X_{t-1}^4 \\
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-1}^1 \quad \Delta X_{t-1}^2 \quad \Delta X_{t-1}^3 \quad \Delta X_{t-1}^4
## \end{smatrix}
## +\begin{smatrix} %Lag2
## -0.1564 & 0.3057 & -0.3676 & 0.3397 \quad \Delta X_{t-1}^1 \\
## -0.3256 & 0.4169 & -0.1375 & -0.1323 \quad \Delta X_{t-1}^2 \\
## -0.2286 & 0.1986 & -0.1422 & 0.0289 \quad \Delta X_{t-1}^3 \\
## -0.1861 & 0.1163 & -0.1005 & 0.0754 \quad \Delta X_{t-1}^4 \\
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-1}^1 \quad \Delta X_{t-1}^2 \quad \Delta X_{t-1}^3 \quad \Delta X_{t-1}^4
## \end{smatrix}
## +\begin{smatrix} %Lag3
## -0.0997 & 0.1720 & -0.5060 & 0.0753 \quad \Delta X_{t-1}^1 \\
## -0.1731 & 0.5701 & -0.8548 & 0.2004 \quad \Delta X_{t-1}^2 \\
## -0.0949 & 0.3247 & -0.4710 & 0.0330 \quad \Delta X_{t-1}^3 \\
## -0.0173 & 0.1640 & -0.3566 & 0.1234 \quad \Delta X_{t-1}^4 \\
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-1}^1 \quad \Delta X_{t-1}^2 \quad \Delta X_{t-1}^3 \quad \Delta X_{t-1}^4
## \end{smatrix}
## +\begin{smatrix} %Lag4
```

```

## 0.1113 & 0.0115 & -0.2182 & -0.2649 \\
## -0.1334 & 0.1567 & -0.1768 & -0.1456 \\
## -0.0395 & 0.0279 & -0.0157 & -0.2098 \\
## 0.0434 & 0.0920 & -0.0495 & -0.1340
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-4}^{\{1\}} \ \ \ \Delta X_{t-4}^{\{2\}} \ \ \ \Delta X_{t-4}^{\{3\}} \ \ \ \Delta X_{t-4}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## \quad \quad \quad \%Lag5
## -0.2077 & 0.6442 & -0.3450 & -0.1221 \\
## -0.1489 & 0.4225 & -0.3238 & -0.0902 \\
## -0.0798 & 0.4677 & -0.5097 & 0.0225 \\
## -0.0149 & 0.2602 & -0.2342 & -0.0428
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-5}^{\{1\}} \ \ \ \Delta X_{t-5}^{\{2\}} \ \ \ \Delta X_{t-5}^{\{3\}} \ \ \ \Delta X_{t-5}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## \quad \quad \quad \%Lag6
## -0.3018 & 0.2644 & -0.1907 & -0.3047 \\
## -0.2042 & 0.2872 & -0.0082 & -0.5614 \\
## -0.2212 & 0.0158 & 0.0724 & -0.2018 \\
## -0.1197 & -0.0031 & 0.1004 & -0.0691
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-6}^{\{1\}} \ \ \ \Delta X_{t-6}^{\{2\}} \ \ \ \Delta X_{t-6}^{\{3\}} \ \ \ \Delta X_{t-6}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## \quad \quad \quad \%Lag7
## 0.0053 & 0.3171 & -0.6856 & 0.0968 \\
## -0.2375 & 0.4487 & -0.2006 & -0.3100 \\
## -0.0007 & 0.1588 & -0.1589 & -0.1610 \\
## -0.0577 & 0.1013 & -0.0474 & -0.0371
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-7}^{\{1\}} \ \ \ \Delta X_{t-7}^{\{2\}} \ \ \ \Delta X_{t-7}^{\{3\}} \ \ \ \Delta X_{t-7}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## \quad \quad \quad \%Lag8
## 0.0444 & 0.1851 & -0.7204 & 0.7122 \\
## -0.0760 & 0.2906 & -0.6035 & 0.3364 \\
## 0.0180 & 0.2463 & -0.3677 & 0.2337 \\
## 0.0141 & 0.0733 & -0.1914 & 0.2309
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-8}^{\{1\}} \ \ \ \Delta X_{t-8}^{\{2\}} \ \ \ \Delta X_{t-8}^{\{3\}} \ \ \ \Delta X_{t-8}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## \quad \quad \quad \%Lag9
## 0.0824 & 0.0734 & -0.3254 & -0.0891 \\
## 0.0010 & 0.1331 & -0.6844 & 0.4762 \\
## 0.0324 & 0.1087 & -0.2191 & 0.0171 \\
## 0.0021 & 0.0403 & -0.0851 & -0.0276
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-9}^{\{1\}} \ \ \ \Delta X_{t-9}^{\{2\}} \ \ \ \Delta X_{t-9}^{\{3\}} \ \ \ \Delta X_{t-9}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## \quad \quad \quad \%Lag10

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## 0.1211 & 0.5152 & -0.5981 & -0.2266 \\
## 0.0458 & 0.2849 & -0.4099 & 0.0633 \\
## 0.0554 & 0.1957 & -0.3162 & -0.0478 \\
## 0.0662 & 0.0334 & -0.1484 & 0.0838
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-10}^{\{1\}} \\ \Delta X_{t-10}^{\{2\}} \\ \Delta X_{t-10}^{\{3\}} \\ \Delta X_{t-10}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## %Lag11
## -0.2219 & 0.5793 & 0.0815 & -0.3171 \\
## -0.0949 & 0.6257 & -0.1002 & -0.6105 \\
## -0.1033 & 0.3420 & -0.0511 & -0.1430 \\
## -0.0419 & 0.0420 & 0.2507 & -0.1524
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-11}^{\{1\}} \\ \Delta X_{t-11}^{\{2\}} \\ \Delta X_{t-11}^{\{3\}} \\ \Delta X_{t-11}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## %Lag12
## 0.1538 & 0.2807 & -0.5864 & 0.0384 \\
## 0.0889 & 0.3406 & -0.3070 & -0.1112 \\
## 0.1084 & 0.1727 & -0.2049 & -0.0049 \\
## 0.0155 & 0.1966 & 0.0017 & -0.1682
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-12}^{\{1\}} \\ \Delta X_{t-12}^{\{2\}} \\ \Delta X_{t-12}^{\{3\}} \\ \Delta X_{t-12}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## %Lag13
## 0.0051 & 0.0912 & -0.2028 & -0.0126 \\
## -0.2529 & 0.5162 & -0.1988 & -0.1029 \\
## -0.1452 & 0.3347 & 0.0585 & -0.2342 \\
## -0.0970 & 0.2406 & 0.0448 & -0.2106
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-13}^{\{1\}} \\ \Delta X_{t-13}^{\{2\}} \\ \Delta X_{t-13}^{\{3\}} \\ \Delta X_{t-13}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## %Lag14
## -0.0488 & 0.0069 & 0.2657 & -0.4594 \\
## -0.0139 & 0.1130 & -0.0680 & -0.2087 \\
## -0.0867 & -0.0227 & 0.2567 & -0.3035 \\
## -0.0793 & -0.1267 & 0.3019 & -0.1866
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-14}^{\{1\}} \\ \Delta X_{t-14}^{\{2\}} \\ \Delta X_{t-14}^{\{3\}} \\ \Delta X_{t-14}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## %Lag15
## 0.3308 & 0.0176 & -0.3174 & -0.0854 \\
## 0.2189 & -0.1189 & -0.2024 & -0.0024 \\
## 0.0464 & -0.0180 & 0.0495 & -0.1606 \\
## 0.0149 & -0.0636 & 0.0279 & -0.0411
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-15}^{\{1\}} \\ \Delta X_{t-15}^{\{2\}} \\ \Delta X_{t-15}^{\{3\}} \\ \Delta X_{t-15}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}
## %Lag16

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## -0.0167 & 0.3100 & -0.1634 & -0.0327 \\
## 0.1988 & 0.1121 & 0.2180 & -0.5649 \\
## 0.0818 & 0.1087 & 0.1271 & -0.3075 \\
## 0.0798 & -0.0304 & 0.1937 & -0.2006
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-16}^{\{1\}} \\\Delta X_{t-16}^{\{2\}} \\\Delta X_{t-16}^{\{3\}} \\\Delta X_{t-16}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}          %Lag17
## -0.0203 & 0.3009 & 0.0639 & -0.2289 \\
## -0.0822 & 0.3179 & -0.1404 & -0.1932 \\
## -0.1064 & 0.1648 & 0.0156 & 0.0188 \\
## -0.0104 & 0.0963 & -0.0460 & 0.0208
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-17}^{\{1\}} \\\Delta X_{t-17}^{\{2\}} \\\Delta X_{t-17}^{\{3\}} \\\Delta X_{t-17}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}          %Lag18
## 0.1451 & 0.0269 & -0.0969 & -0.2324 \\
## 0.0574 & 0.2002 & 0.0236 & -0.4791 \\
## -0.0082 & 0.0817 & 0.1297 & -0.3181 \\
## -0.0031 & 0.0900 & 0.0671 & -0.1963
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-18}^{\{1\}} \\\Delta X_{t-18}^{\{2\}} \\\Delta X_{t-18}^{\{3\}} \\\Delta X_{t-18}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}          %Lag19
## -0.1748 & -0.0022 & 0.0775 & 0.0964 \\
## -0.0671 & 0.1469 & -0.2616 & -0.0005 \\
## -0.0602 & -0.0365 & -0.0184 & -0.0423 \\
## -0.0603 & -0.0297 & -0.0176 & -0.0111
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-19}^{\{1\}} \\\Delta X_{t-19}^{\{2\}} \\\Delta X_{t-19}^{\{3\}} \\\Delta X_{t-19}^{\{4\}}
## \end{smatrix}
## +\begin{smatrix}          %Lag20
## -0.0933 & 0.1971 & 0.1295 & -0.4883 \\
## -0.1224 & 0.1060 & 0.1544 & -0.2661 \\
## -0.0088 & 0.0757 & 0.2121 & -0.4877 \\
## 0.0215 & -0.0223 & 0.1039 & -0.2263
## \end{smatrix}
## \begin{smatrix}
## \Delta X_{t-20}^{\{1\}} \\\Delta X_{t-20}^{\{2\}} \\\Delta X_{t-20}^{\{3\}} \\\Delta X_{t-20}^{\{4\}}
## \end{smatrix}
## \end{equation}

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