Investing with cryptocurrencies – A liquidity constrained investment approach

Simon Trimborn
Mingyang Li
Wolfgang Karl Härdle

Ladislaus von Bortkiewicz Chair of Statistics
Humboldt-Universität zu Berlin
Department of Statistics and Applied Probability
National University of Singapore
Xiamen University

http://lvb.wiwi.hu-berlin.de
https://www.stat.nus.edu.sg
http://wise.xmu.edu.cn
The emergence of cryptocurrencies

- Satoshi Nakamoto found Bitcoin in 2009
- 1595 cryptos (10.05.2018)
- Market cap: 430 billion USD
- 24h trading volume: 22 billion USD
- Community driven currencies
- Source codes public
**Crypto market: high return**

Figure 1: [hu.berlin/crix](https://hu.berlin/crix)

Reference: [Trimborn and Härdle (2017)](https://hu.berlin/crix)

Investing with cryptocurrencies
Low correlation with conventional assets

<table>
<thead>
<tr>
<th></th>
<th>BTC</th>
<th>ETH</th>
<th>XRP</th>
<th>MAID</th>
<th>LTC</th>
<th>XEM</th>
<th>DASH</th>
<th>ETC</th>
<th>DOGE</th>
<th>XMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>USD/EUR</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.04</td>
<td>-0.01</td>
<td>-0.04</td>
<td>0.00</td>
<td>0.02</td>
<td>0.01</td>
<td>-0.02</td>
<td>-0.04</td>
</tr>
<tr>
<td>JPY/USD</td>
<td>0.00</td>
<td>-0.02</td>
<td>-0.03</td>
<td>0.00</td>
<td>-0.02</td>
<td>-0.01</td>
<td>0.06</td>
<td>0.03</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>USD/GBP</td>
<td>-0.05</td>
<td>-0.05</td>
<td>0.03</td>
<td>-0.01</td>
<td>-0.06</td>
<td>-0.12</td>
<td>0.00</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.03</td>
</tr>
<tr>
<td>Gold</td>
<td>0.05</td>
<td>0.03</td>
<td>0.04</td>
<td>0.06</td>
<td>0.04</td>
<td>0.05</td>
<td>0.00</td>
<td>-0.01</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>SP500</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.05</td>
<td>0.01</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>XWD</td>
<td>0.02</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.04</td>
<td>-0.04</td>
<td>0.00</td>
<td>0.04</td>
<td>0.02</td>
<td>0.00</td>
<td>0.07</td>
</tr>
<tr>
<td>EEM</td>
<td>-0.02</td>
<td>-0.03</td>
<td>0.02</td>
<td>0.01</td>
<td>-0.04</td>
<td>-0.01</td>
<td>0.03</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>REIT</td>
<td>0.02</td>
<td>-0.04</td>
<td>0.02</td>
<td>0.01</td>
<td>0.03</td>
<td>0.07</td>
<td>-0.02</td>
<td>0.01</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>DTB3</td>
<td>0.05</td>
<td>0.04</td>
<td>0.06</td>
<td>0.01</td>
<td>0.04</td>
<td>0.02</td>
<td>0.05</td>
<td>0.03</td>
<td>-0.01</td>
<td>0.07</td>
</tr>
<tr>
<td>DGS10</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
<td>-0.04</td>
<td>0.01</td>
<td>0.01</td>
<td>0.02</td>
<td>-0.07</td>
<td>0.00</td>
<td>-0.01</td>
</tr>
</tbody>
</table>

Table 1: Correlations between cryptos and conventional financial assets: 3 exchange rates, gold, 3 stock indices, real estate and the US Treasury Bills Rates.

Source: Elendner et al. (2017)
Effect from world politics on BTC

While the world's attention is on the US election, #cryptocurrency market is gaining intraday crix.hu-berlin.de

Figure 2: Possible effect of notification about Trump's election success on Bitcoin
Investing with cryptocurrencies
Trading platforms

- Trading 24/7
- Against other crypto-currencies and USD, EUR, ruble
- Examples
  - Poloniex
  - btc-e
  - Kraken
  - ...

Investing with cryptocurrencies
Initial Coin Offerings (ICO)

- Basically similar to an IPO
- Opportunity to get easy access to VC
- Only runs on Blockchains for Crypto assets
- Opportunity to collect money anonymously
- Became restricted in several countries (USA, China, Singapore)
Information platforms

- Bitcoin data: blockchain.info
- Bitcoin price: Coindesk Bitcoin price index
- Altcoin data: CoinMarketCap.com
- Altcoin ranking: CoinGecko.com
- Index data: crix.hu-berlin.de
Cryptos from an investment viewpoint

- Chen et al. (2017): Analyzing dynamics of CRIX.
Cryptos from an investment viewpoint II

- Hafner (2018): Cryptos show frequent bubble behavior
- Scaillet et al. (2018): High tail risk
- Bouri et al. (2016): Bitcoin as hedge, save haven or diversifier?
- Klein et al. (2018): Bitcoin is not the new gold
Challenge 1: high risk

Figure 3: Cryptocurrencies have higher volatilities than stocks, highlighting the importance of risk management when investing on them.
Challenge II: low trading volume

Figure 4: Cryptocurrencies have much lower trading volume compared to traditional assets.
Investment strategies

- Volatility based: Markowitz
- Quantile based: Conditional Value-at-Risk
- Quantile & shrinkage: TEDAS
- LASSO: Smaller tracking portfolios

But:

- Perfect liquidity is assumed
- Might not hold in crypto markets
Challenges

- Adding low liquidity cryptocurrencies into standard portfolio
- Investment portfolios under liquidity restrictions
- How to measure liquidity?
- Errors due to chosen liquidity measure?
Outline

1. Motivation ✓
2. Optimization method
3. Data
4. Empirical results
5. Appendix
Optimization problem 1
Target optimization problem:

$$\begin{align*}
\text{min} & \quad w^T \hat{\Sigma} w \\
\text{s.t.} & \quad \mu \leq w^T r, \quad 1_p^T w = 1, \quad ||w||_1 = 1, \\
& \quad w \leq \frac{1}{M} \cdot \hat{\text{Liq}} = \hat{a},
\end{align*}$$

- $\hat{\text{Liq}} = (TV_1 \cdot f_1, \cdots, TV_N \cdot f_N)^T$
- $\hat{\Sigma}$: estimated covariance matrix
- $w = (w_1, w_2, \cdots, w_p)^T$: weight on assets
- $1_p^T = (1, 1, \cdots, 1)_{(1 \times p)}$
- $M$: investment amount
- $\mu$: target return

Investing with cryptocurrencies
Optimization problem II

Target optimization problem:

\[
\begin{align*}
\min & \quad \text{CVaR}_\alpha\left( w \right) \\
\text{s.t.} & \quad \mu \leq w^\top r, \ 1_p^\top w = 1, \ \|w\|_1 = 1, \\
& \quad w \leq \frac{1}{M} \cdot \hat{\text{Liq}} = \hat{a}.
\end{align*}
\]

\begin{itemize}
  \item \( \text{CVaR}_\alpha\left( w \right) = \frac{1}{1-\alpha} \int_{f(w,r) \geq \text{VaR}_\alpha} f(w,r)p(r)dr \)
  \item \( \text{VaR}_\alpha = \inf \{ r | F(w,r) \geq \alpha \} \)
\end{itemize}
Data Information

- 42 crypto currencies
- S&P100 component (99 stocks)
- Barclays Capital US Aggregate Index (US-Bonds Index)
- S&P GSCI (Commodities Index)
- 2014-04-01 to 2017-10-30
Setting

- $f_1, \ldots, f_N = 0.01$
- $TV_i$: Median of daily turnover values
- Expanding window for estimation, Monthly rebalanced
- Robustness test with weekly rebalancing
- Markowitz: $\mu$ chosen by $\max w^\top r/\tilde{w}^\top \tilde{\Sigma} \tilde{w}$
- CVaR: $\mu$ chosen by $\max w^\top r/|\text{CVaR}_\alpha(w)|$
In-sample: CVaR & Markowitz portfolios

Figure 5: Lines indicate cumulative return of Markowitz (solid) and CVaR (dashed) portfolios respectively. S and S-CC portfolio.

Investing with cryptocurrencies
In-sample with bounds

Figure 6: S and S-CC Markowitz portfolios are without liquidity constraints, the remaining 3 portfolios are S-CC ones containing the bounds $M = 1 \times 10^5 \text{ USD}$, $M = 1 \times 10^6 \text{ USD}$, $M = 1 \times 10^7 \text{ USD}$. 

Investing with cryptocurrencies
In-sample with bounds

Figure 7: SBC and SBC-CC Markowitz portfolios are without liquidity constraints, the remaining 3 portfolios are SBC-CC ones containing the bounds $M = 1 \times 10^5$ USD, $M = 1 \times 10^6$ USD, $M = 1 \times 10^7$ USD.
Empirical Results

Out-of-sample: Markowitz & S&P100

Figure 8: S and S-CC are monthly adjusted portfolios without liquidity constraints, while the remaining 3 portfolios are S-CC ones containing bounds $M = 1 \times 10^5$ USD, $M = 1 \times 10^6$ USD, $M = 1 \times 10^7$ USD.
Out-of-sample: CVaR & S&P100

Figure 9: S and S-CC are monthly adjusted portfolios without liquidity constraints, while the remaining 3 portfolios are S-CC ones containing bounds \( M = 1 \times 10^5 \) USD, \( M = 1 \times 10^6 \) USD, \( M = 1 \times 10^7 \) USD.
Investing with cryptocurrencies
Empirical Results

Out-of-sample monthly adjusted CVaR portfolio weights

Investing with cryptocurrencies
Conclusion

- We propose LIBRO: LIquidity Bounded Risk-return Optimization
- Including cryptos can provide better risk-return trade off
- Cryptos beside Bitcoin matter for portfolio optimization
- Less frequent adjustment (monthly contra weekly) enhances results
- LIBRO even enhances results in traditional markets
Investing with cryptocurrencies – A liquidity constrained investment approach

Simon Trimborn
Mingyang Li
Wolfgang Karl Härdle

Ladislaus von Bortkiewicz Chair of Statistics
Humboldt–Universität zu Berlin
Department of Statistics and Applied Probability
National University of Singapore
Xiamen University

http://lvb.wiwi.hu-berlin.de
https://www.stat.nus.edu.sg
http://wise.xmu.edu.cn
Bibliography I

Hermann Elendner, Simon Trimborn, Bobby Ong and Teik Ming Lee (2017)
The Cross-Section of Cryptocurrencies as Financial Assets

David Yermack (2015)
Is Bitcoin a Real Currency? An Economic Appraisal
Bibliography II

Simon Trimborn, Mingyang Li and Wolfgang Karl Härdle (2017)
Investing with Cryptocurrencies - A Liquidity Constrained Investment Approach
SFB 649 Economic Risk Discussion Paper

Marie Brière, Kim Oosterlinck and Ariane Szafarz (2015)
Virtual currency, tangible return: Portfolio diversification with bitcoin
Journal of Asset Management 16.6, pp. 365-373
Bibliography III

Simon Trimborn and Wolfgang Karl Härdle (2017)
CRIX an Index for cryptocurrencies
SFB 649 Economic Risk Discussion Paper, revise and resubmit
Journal of Empirical Finance

Wolfgang Karl Härdle and Simon Trimborn (2015)
CRIX or evaluating Blockchain based currencies

Back to high return

Investing with cryptocurrencies
Bibliography IV

Caveat Emptor: Does Bitcoin Improve Portfolio Diversification?
SSRN Scholarly Paper

Shi Chen, Cathy Yi-Hsuan Chen, Wolfgang Karl Härdle, Bobby Ong and Teik Ming Lee (2017)
Econometric Analysis of a Cryptocurrency Index for Portfolio Investment