CRIX or evaluating blockchain based currencies

Simon Trimborn
Wolfgang Karl Härdle

Ladislaus von Bortkiewicz Chair of Statistics
C.A.S.E. – Center for Applied Statistics and Economics
Humboldt-Universität zu Berlin
http://lvb.wiwi.hu-berlin.de
http://www.case.hu-berlin.de
Currencies - Cigarettes, USD, Cryptos

- Anything can be a currency
- Anyone can offer a currency

Figure 1: Cigarette trading in postwar Germany (42)
Figure 2: Friedrich A. Hayek (42)

CRIX - a CRyptocurrency InDeX
Digital Economy

- Amazon
- Paypal
- Google Wallet
- Cryptocurrencies
- Ripple

CRIX - a CRyptocurrency IndeX
Cryptocurrencies

- Decentralized, virtual, low transaction costs

- NYSE, Andreessen Horowitz, DFJ: Coinbase funding (75 M$)
- Nasdaq: company-wide utilization of blockchain technology
- Citigroup: own coin development
- PBOC: working on digital currency
- Switzerland: first city accepts Bitcoin payments
Cryptocurrencies – Facts

- As of 20160531, CoinMarketCap.com
  - 632 cryptos
  - 2,034 exchange pairs
  - Market Cap 10.6 billion USD

- Barely derivatives

- Commodity Futures Trading Commission (USA)
  - Cryptos are commodities
Challenges

- What is the benchmark?
- How does the market evolve?
- Market index necessary to compare cryptos
What is the benchmark?

Figure 3: Wilshire 5000 Total Market Index, S&P500, S&P100, rescaled to a starting value of 1000

CRIX - a CRyptocurrency Index
CRIX - the benchmark

Figure 4: Screenshot: crix.hu-berlin.de
Outline

1. Motivation ✓
2. Market Index - CRIX
3. CRIX family comparison
4. Application to German stock market
5. Application to Mexican stock market
6. Conclusion
7. Appendix
Data

- 290 cryptos
- Time period: 20140401 - 20160406
- Prices, capitalization, volumes
- CoinGecko
CRIX – Rules I

Laspeyres’ idea:

\[
\text{CRIX}(k)_t = \frac{\sum_{j=1}^{k} MV_{jt}}{\text{Divisor}}
\]

- \( MV_{jt} \): market capitalization of crypto \( j \)
- \( k \): number of constituents

Liquidity rule:
- Eligible if higher rank than 0.25 percentile
- Measure regarding daily volume in USD and coins
CRIX - Rules II

- **Spine**
  - Index members
  - Crucial for benchmark fit

\[
CRIX(k)_t \xrightarrow{\text{min}(k)} \text{total market}_t
\]

- total market\(_t\) = \[\sum_{j=1}^{J} \frac{MV_{jt}}{\text{Divisor}}\]

- **Quadratic loss function**

- **Sparse benchmark**
CRIX - Rules III

1. Construct total market index: \( \text{total market}_t = \frac{\sum_{j=1}^{J} \text{MV}_{jt}}{\text{Divisor}} \)

2. Set \( i = 1 \)

3. Construct \( \text{CRIX}(k_i), \ i = 1, 2, 3, \ldots, \ k_1 < k_2 < k_3 < \ldots \)

4. Compute \( \varepsilon(k_i)_t = \text{total market}_t - \text{CRIX}(k_i)_t \)

5. Kernel density estimation for density \( f(\varepsilon(k_i)_t) \) with leave-one-out cross validation

6. Derive \( AIC(k_i) = -2 \log \prod_{t=1}^{n} f(\varepsilon(k_i)_t) + 2k_i \)

7. If \( i = 1 \): Jump to 3., else 8.

8. If \( AIC(k_{i-1}) < AIC(k_i) \): stop, else jump to 3. and \( i = i + 1 \)
CRIX – Rules IV

- AIC asymp. optimal - Benchmark
  - Best model out of model set
  - Minimization of K-L information loss by approximating full reality
CRIX family

- CRIX - AIC
  - $k_1 = 5$
  - Step width: 5 constituents
  - Local optimum

- ECRIX - AIC
  - $k_1 = 1$
  - Step width: 1 constituents
  - Local optimum

- EFCRIX - AIC
  - $k_1 = 1$
  - Step width: 1 constituents
  - Optimum

CRIX - a CRyptocurrency IndeX
# Index members

- Compare last 3 M
- Amount used for next 3 M

<table>
<thead>
<tr>
<th>Period</th>
<th>CRIX</th>
<th>ECRIX</th>
<th>EFCRIX</th>
<th>Maximum achievable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>3</td>
<td>40</td>
<td>41</td>
</tr>
<tr>
<td>2</td>
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<td>4</td>
<td>30</td>
<td>10</td>
<td>190</td>
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</tr>
<tr>
<td>5</td>
<td>15</td>
<td>2</td>
<td>204</td>
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<tr>
<td>7</td>
<td>55</td>
<td>4</td>
<td>214</td>
<td>214</td>
</tr>
</tbody>
</table>

Table 1: Number of constituents in respective periods

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CRIX performance

Figure 5: CRIX CRIXindex CRIXcode

CRIX - a CRyptocurrency IndeX
Loss comparison I

Figure 6: Realized difference between total market and CRIX, ECRIX, EFCRIX

CRIX - a CRypocurrency Index
## Loss comparison II

Table 2: Comparison of CRIX, ECRIX, EFCRIX against total market

<table>
<thead>
<tr>
<th></th>
<th>MSE</th>
<th>MDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRIX vs. Total Market</td>
<td>2.0687</td>
<td>0.9935</td>
</tr>
<tr>
<td>ECRIX vs. Total Market</td>
<td>9.2370</td>
<td>0.9870</td>
</tr>
<tr>
<td>EFCRIX vs. Total Market</td>
<td>0.0503</td>
<td>1.0000</td>
</tr>
</tbody>
</table>
CRIX methodology & German stock market

- German Prime Standard
- Basis for DAX, MDAX, SDAX, TecDAX
- DAX often interpreted as market indicator
- DAXCRIX
  - CRIX methodology applied to German companies
  - Initialization with 30 members
  - Time period: 20000616 - 20151218
  - AIC computation quarterly
  - Index members exchange quarterly

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Index members FDAX

Comparison of DAX and FDAX index members

Figure 7: Number of constituents in respective periods for DAX and FDAX

CRIX - a CRyptocurrency InDeX
Loss comparison DAX & FDAX

<table>
<thead>
<tr>
<th></th>
<th>MSE</th>
<th>MDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>FDAX vs. TMI</td>
<td>347.20</td>
<td>0.95</td>
</tr>
<tr>
<td>DAX vs. TMI</td>
<td>756.47</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Table 3: Comparison of DAX with CRIX methodology (FDAX) and rescaled DAX against total market. FDAXloss, CRIXcode.
CRIX methodology & Mexican stock market

- Unique condition: Telecommunication sector dominant
- Carlos Slim Helu
- IPC35 meant as market indicator
- FIPC
  - CRIX methodology applied to Mexican stock market
  - Initialization with 35 members
  - Time period: 19960601 - 20150529
  - All Mexican companies in Datastream
  - AIC computation quarterly
  - Index members exchange quarterly

CRIX - a CRyptocurrency InDeX
Loss comparison IPC & FIPC

<table>
<thead>
<tr>
<th></th>
<th>MSE</th>
<th>MDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIPC vs. TMI</td>
<td>242.07</td>
<td>0.97</td>
</tr>
<tr>
<td>IPC vs. TMI</td>
<td>151113.43</td>
<td>0.91</td>
</tr>
</tbody>
</table>

Table 4: Comparison of IPC with CRIX methodology (FIPC) and rescaled IPC against total market
Conclusion

- CRIX represents market very well
- EFCRIX best but too many index constituents
- CRIX good choice in terms of MSE and MDA
- Methodology enhances fit to German stock market
  - But strategy may cause high transaction costs
  - Use analysis to identify lower bound of index members
- Methodology performs even better applied to Mexican stock market

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Bibliography

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CRIX or evaluating Blockchain based currencies
SFB Discussion Paper

Simon Trimborn and Wolfgang Karl Härdle (2015)
CRIX or evaluating Blockchain based currencies
DOI: 10.4171/OWR/2015/42
Bitcoin

- Counteract inflation
  - Fixed max amount
- Anonymity
- Needs of users
  - Decision on structure

Movie: Bitcoin - Made simple
Anonymity - Black market

- Wallets are anonym
- Transactions are anonym
- Blockchain core feature
- Causes problems

Figure 8: US government warning
Source: www.wikipedia.org
The Blockchain - Spine of Bitcoin

- Transaction list
- Transaction processors called miners
- Miners collect & publish transactions
- Order is invariable

Figure 9: Spine
The Blockchain

- Sometimes parallel chains
  - Due to e.g. internet lag
- Green block: first block
  (Genesisblock)
- Black blocks: main chain
- Purple blocks: parallel chains

Figure 10: Blockchain
Source: www.wikipedia.de
The Blockchain – Lag

- Assume: 2 blocks mined simultaneously
  - Miner 1: Australia
  - Miner 2: Germany

- Effect of lag:
  - Some receive Australian block
  - Some receive German block

- Parallel chain

- For next block:
  - Check which chain contains the most difficult to find blocks
  - Becomes main chain
Process of Transactions

- Users organize process
- Some users (miners) create a transaction list
  - Next block of blockchain
- Blocks have a strict order, ensured by signature
- Miners search for signature
- Signature encrypted by cryptography

Transaction example

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Who accepts Bitcoin?

- Overstock - Retailer
- Dell
- University of Cumbria
- Expedia - Travel Agency
- Republican Party of Louisiana
Bitcoin - The System I

- Take 4 people
  - Alice, Bob
  - Gary, Grace
- 2 special users (miners)
  - Gary
  - Grace
- Alice buys a rare book from Bob and pays with Bitcoin
- Gary and Grace process this transaction
Bitcoin - The System II

Alice

Gary

Grace

Bob

block

CRIX - a CRypocurrency IndeX
Appendix

Bitcoin - The System III

- Gary OR Grace receives Bitcoins for service
- BOTH add transaction to list
- BOTH compute hash value (trial and error)
- Click for online hash generator
- List: one block of the blockchain
- Hash value: gives position of block in blockchain
- Contains part of hash value of last block

CRIX - a Cryptocurrency Index
Liquidity Rule I

- Rely often on turnover

\[ \text{Turnover} = \frac{\text{Volume}}{\text{Floating Coins}} \]

- Floating Coins for cryptos unclear
- Rule motivated by STOXX Japan 600 and AEX Family
- Measure relative to asset universe
- Small trading volume in USD but high traded coins taken into account
Liquidity Rule II

Liquidity rule (one of these):

1. 0.25 percentile of ADTV (Average Daily Trading Volume):
   \[ ADTV_i \geq ADTV_{0.25} \]

2. 0.25 percentile of ADRTC (Average Daily Relative Traded Coins):
   \[ ADRTC_i \geq ADRTC_{0.25} \]

- Checked monthly
- Crypto made insensitive if trading stops
Usage of Bitcoins

Figure 11: one day, one week, one month, 1-3 month source: John Radcliff

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Kernel Density Estimation (KDE)

- Compute pdf with KDE

\[ \hat{f}_h(x) = \frac{1}{nh} \sum_{i=1}^{n} K \left( \frac{x - X_i}{h} \right) \]

with \( K(u) \) Epanechnikov kernel, \( h \) bandwidth

- Bandwidth selection with Wand & Jones plug-in estimator
References

- Cigarette trading in postwar Germany, Bundesarchiv, Bild 183-R79014 / CC-BY-SA
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