A Graph-based Algorithm for Finding Arbitrage Oppotunities in the Cryptocurrency Spot Market

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1   Introduction

1.1   Cryptocurrency Spot Market

Cryptocurrencys spot markets are exchanges where people trading their digital coins like Bitcoin, Ethereum, etc. On October 19, 2017, the market capitalizations of the top coins are shown in Table 1.[1]

Coin	Market Cap.	Price	Volume (24h)
Bitcoin	\$102,461,472,454	\$6158.66	\$2,708,970,000
Ethereum	\$28,154,471,164	\$295.64	\$451,489,000
Ripple	\$7,867,600,806	\$0.20	\$136,479,000
Bitcoin Cash	\$5,375,340,170	\$321.73	\$158,438,000
Litecoin	\$3,155,405,470	\$59.01	\$176,593,000

Table 1: Cryptocurrencys market capitalizations

Many exchanges not only offers trading pairs between digital coins and government-issued currencies, but also supports the trading between diffrent coins. This enables some trading strategies like triangular arbitrage.

Another notable feature of the cryptocurrency spot market is that some exchanges charges no trading fees (e.g. OKEx), thus we can trade very rapidly, no matter how small the profit is.

1.2   Triangular Arbitrage

Suppose we have x_i dollars. If we use them to buy some bitcoins, then use these bitcoins to buy ethereums, and finally sell those ethereums for x_f dollars. If $x_f > x_i$, a profit is realized. Since the cryptocurrency spot market is active, we can expect $x_f - x_i$ is very small, and only occurs at minute or second time scale.

Triangular arbitrage opportunities can be identified through the rate product

$$\gamma(t) = \prod_{i=1}^{3} r_i(t)$$

where $r_i(t)$ denotes an exchange rate at time t. An arbitrage is theoretically possible if $\gamma > 1$. For each group of exchange rates there are two unique rate products that can be calculated. For example, consider the set of rates {BTC/USD, ETH/USD, ETH/BTC}. If one initially holds US dollars, a possible arbitrage transaction sequence is USD→BTC→ETH→USD with the rate product given by

$$\gamma_1(t) = \left[\frac{1}{\text{BTC/USD}_{ask}(t)} \right] \cdot \left[\frac{1}{\text{ETH/BTC}_{ask}(t)} \right] \cdot [\text{ETH/USD}_{bid}(t)]$$

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[1] Source: `coinmarketcap.com`

and the rate product of the other possible trading sequence is

$$\gamma_2(t) = [\text{BTC/USD}_{bid}(t)] \cdot [\text{ETH/BTC}_{bid}(t)] \cdot \left[\frac{1}{\text{ETH/USD}_{ask}(t)} \right]$$

These two rate products define all possible arbitrage transactions using this set of trading pairs.[Fenn et al., 2009]

1.3   Inter-market Arbitrage

Suppose there are two exchange E_1 and E_2 offering the same trading pair ETH/BTC with price $ask_i(t)$ and $bid_i(t)$ at time t, where $i = 1, 2$. An inter-market arbitrage strategy can be buying ETH with BTC in E_1 and then sell them for BTC in E_2. If $ask_1(t) < bid_2(t)$ and you managed to trade at both price, a profit $bid_2(t) - ask_1(t)$ then got realized.

This is pretty similar with the triangular arbitrage described in section 1.2. In fact, we can assume there being two implict trading pair between $\text{BTC}_{E_1}/\text{BTC}_{E_2}$ with both ask and bid price always being 1 (or minus transferring fee rates). The Inter-market arbitrage then become a "quadrangle arbitrage" with all theorems the same as triangular arbitrage except for there being 4 nodes.

1.4   Graph Algorithms

2   Coinflow

3   Experiments

4   Disscussion

References

[Fenn et al., 2009] Fenn, D. J., Howison, S. D., McDonald, M., Williams, S., and Johnson, N. F. (2009). The mirage of triangular arbitrage in the spot foreign exchange market. *International Journal of Theoretical and Applied Finance*, 12(08):1105–1123.