Short Paper: Estimating Profitability of Alternative Cryptocurrencies

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Abstract. Digital currencies have flourished in recent years, buoyed by the tremendous success of Bitcoin. These blockchain-based currencies, called *altcoins*, are associated with a few thousand to millions of dollars of market capitalization. Altcoins have attracted enthusiasts who enter the market by mining or buying them, but the risks and rewards could potentially be significant, especially when the market is volatile. In this work, we estimate the potential profitability of mining and speculating 18 altcoins using real-world blockchain and trade data. Using opportunity cost as a metric, we estimate the mining cost for an altcoin with respect to a more popular but stable coin. For every dollar invested in mining or buying a coin, we compute the potential returns under various conditions, such as time of market entry and hold positions. While some coins offer the potential for spectacular returns, many follow a simple bubble-and-crash scenario, which highlights the extreme risks — and potential gains — in altcoin markets.

1 Introduction

In its nine years of existence, Bitcoin [1] (BTC) has been tremendously popular, reaching billions of dollars of market capitalization at the time of this writing. Its success has inspired the creation of many new digital currencies that borrow Bitcoin's key design principles — a blockchain-based public ledger and a means of acquiring a stake in the currency computationally — and, in many cases, Bitcoin's source code. Today, there are over 1,400 such currencies, collectively called *altcoins*. Unlike Bitcoin, which can be used as a medium of exchange, the vast majority of altcoins appear to serve largely as speculative investment vehicles. The market capitalization and trade volume for a given altcoin can range from thousands to millions of dollars. Whether one believes in a coin's merits or not, altcoins offer ample opportunities for speculation for altcoin investors, especially given the volatile prices. As such, the potential risks and rewards can be significant.

One way to analyze the altcoin market is to look at the profit-driven investors. Among these investors are *miners*, a logical role who expends energy in finding hash collisions to computationally produce the digital assets in a process known as *mining*; and also *speculators*, another logical role who takes advantage of the price volatility of altcoins and profits from speculation.[1] An investor has the flexibility to choose to

[1] We are aware that there are many ways to profit from altcoins, including gaming the mining protocol [2,3] or trading altcoins as if they were penny stocks [4,5]. It is beyond the scope of this paper to discuss all these ways. Furthermore, there may be other participants in the altcoin ecosystem that are not necessarily profit-driven; again, these participants are beyond the our scope.

become a miner and/or a speculator at any point in time. To enter the altcoin market, an investor can mine an altcoin or buy it from the market. If she mines some units of an altcoin,[2] she can further hold onto the coin units and sell them when the price rises, thereby speculating in addition to mining.

The fluidity of these roles makes it difficult for us to retroactively analyze profitability. While existing techniques can potentially help us identify the transfer of altcoins to and from exchanges [6], blockchains frequently do not record when and how many altcoins are internally traded at exchanges; thus, it is difficult to track the profitability of individual investors. Instead, we develop a set of techniques to analyze the potential profitability of particular altcoin investment stategies, from the collective perspectives of miners and speculators. Specifically, our analysis asks these questions: (1) For every $1 of investment, what is the potential profitability of mining versus speculating an altcoin? (2) How does the potential profitability of mining/speculating vary across multiple coins?

In this work, we use historical data to retroactively examine the costs and potential revenue of altcoin mining and speculation. We use *opportunity cost* to compare the relative cost of mining across different altcoins as viewed by a profit-driven miner. Furthermore, we artificially construct simple investment strategies that miners and speculators could have followed — for example, holding units of an altcoin for a fixed period of time before liquidating, without considering the market. We retroactively simulate these strategies to estimate the potentially profitability of miners and speculators. Using this entirely descriptive rather than prescriptive method, we make the following observations based on the altcoins we study. Miners who mine an altcoin immediately after it is listed on exchanges tend to enjoy higher potential returns than miners who mine on subsequent days. In contrast, speculators who buy an altcoin shortly after it is listed on exchanges are likely to generate lower returns than speculators who buy at a later point, and they also generate lower returns than miners in the same period. A more detailed description of our study, including additional findings, can be found in the technical report [7].

2 Methodology

To estimate the potential profitability of mining and speculating across different altcoins, we use historical blockchain and trade data for 18 altcoins, along with Bitcoin (BTC) and Litecoin (LTC). This data contains detailed block metadata, such as the reward and difficulty of each block, along with daily aggregated trade statistics, such as the mean price and trade volume every day. We show these 18 altcoins in the first column of **Table 1**. A full description of our data collection and clean-up process is available in our technical report [7]. In this section, we describe how we use this data to estimate the cost of mining and profitability.

Estimating the cost of mining: In order for profit-driven miners to decide which coin to mine through proof-of-work, they first need to estimate the cost of mining each coin.

[2] Throughout this paper, we use "altcoin" or "coin" interchangeably to refer to the cryptocurrency. In contrast, we use "units" to refer to individual units of reward as a result of mining an altcoin.

However, the precise value is difficult to calculate, as the capital investment and energy costs differ across individual miners. As an alternative to direct costs, we instead consider opportunity cost. Economists consider the opportunity cost of an activity to be the revenue lost by engaging that activity *rather than its best alternative*. We apply the same idea to altcoin mining. In particular, for two coins based on the same hash function, the real costs of mining one versus the other depends entirely on their respective difficulty, because the underlying unit of work, computing a hash, is the same. For example, XJO is a SHA-256-based altcoin. The opportunity cost of mining XJO is the revenue a miner can expect from mining another SHA-256 currency instead of XJO over the same time period. To be a meaningful concept for the miner, this alternative revenue should be something a miner can reasonably expect to receive *a priori*. In other words, to say that a miner chose to mine A units of XJO rather than receive D US Dollars for mining another currency, the miner must be certain that he could get D US Dollars by choosing the alternative *before* choosing one or the other. In our comparisons, we use the least volatile alternative currencies with the highest trade volumes. For SHA-256-based coins, this is Bitcoin; for Scrypt-based coins, this is Litecoin. We call the currency whose opportunity cost we are computing (e.g. XJO) the *target currency*, and Bitcoin or Litecoin the *base currency*.

Formally, we define the opportunity cost of mining a unit of a currency on a given day as follows. First, we determine the expected number of hashes, H, necessary to mine a unit of the target currency based on the difficulty of mining the currency that day. Next, we determine the expected number of units of Bitcoin (for SHA-256-based altcoins) or Litecoin (for Scrypt-based altcoins) that could be mined on that day with H hashes. Finally, we convert this expected number of bitcoins or litecoins to US Dollars at that day's exchange rate. Thus, the opportunity cost of mining a unit of currency X is $\text{OppCost}_X = D_X \cdot R_B / D_B$, where D_X is the expected number of hashes required to mine a unit of X based on the day's difficulty, D_B is the expected number of hashes required to mine a unit of the base currency (Bitcoin or Litecoin) based on the day's difficulty, and R_B is the exchange rate of the base currency, in US Dollars per unit of the currency, on that day. We compute D_X and D_B based on the blockchain data of the target and base currencies, while we obtain R_B from our trade data.

Some altcoins start as simple SHA-256/Scrypt proof-of-work cryptocurrencies, but later change the hash functions or types of proof (such as proof-of-stake). In such circumstances, we consider the history of the currency up to the day of change, so that we can use BTC or LTC as the base currency for calculating opportunity costs of mining from the start of the blockchain to the day of the change. For example, DOGE blocks are based on Scrypt in the first 276 days of the blockchain; afterwards, DOGE allows auxiliary proof-of-work mining (i.e., "merged mining"). As a result, we only consider the first 276 days of the 919-day blockchain for DOGE.

Validation: Focusing on the relevant analysis periods, we compute the opportunity cost, c, of mining a unit of a given coin on a day. From the trade data that we have collected, we can compare it to the market price, p, of the unit on the same day and compute the Pearson correlation coefficient for the daily c and p values. Across the 18 altcoins we study, 12 altcoins are associated with a correlated coefficient > 0.80. (As a comparison, the Dow Jones Industrial Average and the S&P 500 Index between May

2012 and 2017 are correlated with a coefficient of 0.99.) The high correlation between c and p suggests not only is opportunity cost is an effective estimate of the actual mining cost, but that the markets are reasonably efficient. One possible explanation for market efficiency is that as more hype is created around a coin, the market price increases, which in turn attracts more miners. This increases the difficulty of mining and also the opportunity cost, so the opportunity cost goes up along with the price. Conversely, a coin that has attracted a significant amount of hashing capacity has a high difficulty and thus opportunity cost. Thus, miners expect to sell the mined coin units at a higher price. For a detailed analysis of the opportunity cost of mining each altcoin, refer to our technical report [7].

Estimating profitability: Computing the profit obtained by individual actors is difficult, especially when we only have a daily aggregates of the trade data. Instead, we focus on the potential profitability of a dollar invested, either through mining (i.e., \$1 of opportunity cost) or speculating (e.g., literally spending \$1 to buy a given altcoin).

We estimate the profitability of miners through simulation. Using historical blockchain and trade data, we retroactively simulate the investment of \$1 worth of opportunity cost in mining across different altcoins, start dates, and durations — conditions that we have artificially constructed in the hope of covering a diverse range of investment strategies. For speculators, we use a similar simulation, varying the time when an investor enters the market by buying \$1 worth of an altcoin's units, as well as the holding position of the investor. In this way, we can compute the profitability of mining/speculating depending on the participant's strategy. An altcoin market typically has a trade volume much higher than \$1, such that \$1 of mining or speculating is unlikely to change the price significantly. This profitability analysis, while retrospective, assesses the relative risks and rewards for each coin, across multiple coins.

3 Estimating Profitability

In this section, we compute the profitability of miners and speculators for every dollar invested, either by expending \$1 worth of opportunity cost in mining or buying \$1 worth of an altcoin.

Mining: We start by considering the profitability of miners. Using the unit opportunity cost that we computed in the previous section, we construct a simulator in which a miner continuously mines over a duration of d days, starting on Day i. Every day, he invests \$1 worth of opportunity cost in mining. At the end of each day, he sells all the coin units mined on that day. At the end of the d days, his total revenue would be v dollars. We vary i between 1 to $N - d$, where N is the length of the trading period; for instance, $i = 1$ means that our simulated miner starts mining on the day when an altcoin is first listed on an exchange. We also vary d for $d = 1, 7, 30$ days. For all these i and d combinations, we compute the daily average returns, r, by solving for r in this equation: $d(1 + r)^d = v$.

Table 1(a) shows the result of our first simulation, in which a miner continuously mines for $d = 7$ days. The "1st Day r" column shows the value of r if the miner starts mining a coin on Day 1 and continues until Day 7, selling any mined units on the same

Table 1: Mining continuously for 7 and 30 days. All units are in percentages unless otherwise stated.

	(a) 7 Days of Mining					(b) 30 Days of Mining				
Coin	*1st Day* r	$E(r)$	$\sigma(r)$	P	$T_{r\geq 0}$ *(Days)*	*1st Day* r	$E(r)$	$\sigma(r)$	P	$T_{r\geq 0}$ *(Days)*
ARG	4.41	2.61	7.22	76.28	8	-0.51	0.71	1.50	80.71	0
AUR	10.17	0.63	2.25	61.35	19	1.37	0.13	0.35	62.31	18
BTA	6.67	2.01	5.18	69.33	14	0.99	0.45	1.07	68.97	13
CURE	6.23	-6.68	5.92	14.54	18	0.72	-1.54	1.01	8.79	8
DGC	3.24	1.16	2.79	61.66	111	0.77	0.27	0.57	64.89	207
DOGE	70.63	4.22	10.51	100.00	N/A	8.88	0.76	1.31	100.00	N/A
DOT	10.48	18.29	12.12	99.21	14	2.94	4.92	1.15	100.00	N/A
EFL	16.48	2.00	2.07	89.29	30	1.61	0.47	0.34	94.89	18
HAM	13.49	-2.19	6.43	18.82	46	3.10	-0.51	1.30	14.89	65
PPC	0.09	-1.13	1.37	16.50	1	0.02	-0.26	0.17	3.40	4
RPC	10.52	0.74	3.08	59.54	6	0.82	0.17	0.46	59.85	32
SWING	2.74	-2.46	3.77	19.09	3	-0.04	-0.53	0.55	21.83	0
TROLL	-0.01	4.37	1.31	98.08	0	0.87	0.99	0.06	100.00	N/A
UNO	8.44	-5.43	5.52	20.99	79	1.26	-1.34	1.23	15.98	72
VCN	56.98	-2.22	11.77	27.18	34	7.40	-0.75	1.87	30.23	25
VIA	-1.68	2.76	2.09	95.07	0	0.71	0.67	0.33	100.00	N/A
WBB	6.21	6.58	4.45	97.87	83	0.75	1.54	0.78	100.00	N/A
XJO	3.03	-5.51	4.00	4.48	15	0.18	-1.28	0.75	0.83	4

day. In contrast, the "$E(r)$" column computes the expected/mean r if the miner starts mining on a random day. The standard deviation is shown in the "$\sigma(r)$" column. The larger the standard deviation, the higher the risk of investment if a miner starts on a random day. For instance, mining DOT on a random day results in an expected daily return of $18.29 \pm 12.12\%$, which potentially presents a higher reward and risk than mining AUR, with an expected daily return of $0.63 \pm 2.25\%$. We stress that the r value is computed based on a simulated investment of $1 worth of opportunity cost. In total, DOT is associated with $917 of trade volume and $3,198 of total opportunity cost. Even though its r value is high, the amount of actual profit extracted is likely to be limited. In contrast, a PPC miner can generate an expected return of $-1.13 \pm 1.37\%$. Given that PPC is associated with more than $8 million worth of trade volume and $8 million total opportunity cost, an actual miner has the potential to suffer significant losses.

Another way to measure risk is to compute the probability, P, of achieving a positive r if a miner starts mining an altcoin for 7 days on a random start day. As shown in the "P" column, miners of altcoins like DOGE and WBB will earn positive returns on (almost, in the case of WBB) any random start day. XJO miners, by contrast, will earn positive returns on a random start day with a probability of only 4.48%.

We observe that of the 18 altcoins in the table, the 1st Day r values are higher than the corresponding $E(r)$ values in 14 altcoins, which suggests that miners of these 14 coins obtain higher returns if they start mining as soon as an altcoin is listed on an exchange, relative to the average case (i.e. $E(r)$). One possible reason is that when an altcoin is first listed, the amount of mining capacity it has attracted is still on the rise, as there is friction for miners to reconfigure their equipment to mine a new-to-market altcoin; thus the opportunity cost of mining tends to be low in the beginning. Furthermore, the market price is often high when an altcoin is listed — a period typically associated with hype. The gap between high price and low opportunity cost creates a potential for miners to profit during this period.

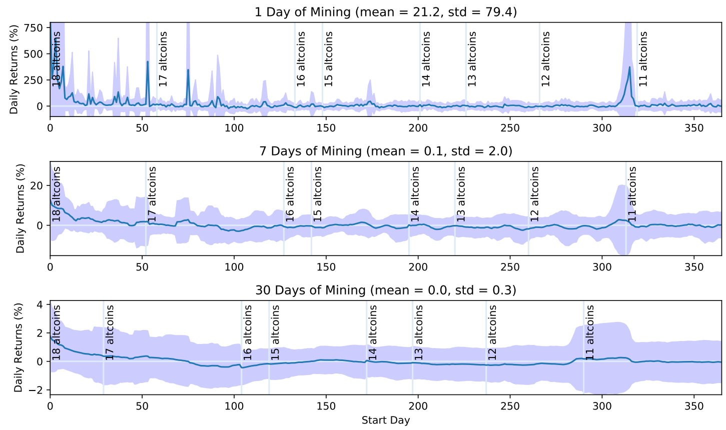

Fig. 1: Potential profitability of mining a random altcoin.

In fact, miners can potentially profit during the first few consecutive days after an altcoin is listed on exchanges. Column "$T_{r\geq 0}$" shows the number of consecutive days since Day 1, such that a miner who starts mining on one of these days and continues for 7 days will not encounter a negative r. For example, an ARG miner who starts mining on any day of the first 8 days will receive $r \geq 0$; if she starts mining on Day 9, she would receive $r < 0$ for the first time (although she could still obtain positive returns subsequently). For TROLL and VIA, the 1st Day r is already negative, so $T_{r\geq 0} = 0$. For DOGE, all r values are positive regardless of the start day; thus $T_{r\geq 0} =$ N/A.

Finally, we repeat the simulation above, changing $d = 30$ days. We show the results in **Table 1**(b). Again, for 14 out of the 18 altcoins, mining on Day 1 will yield a higher r than the expected case. The expected returns are lower for $d = 30$ than $d = 7$ in 11 of the altcoins, while all the $\sigma(r)$ values are smaller.

So far, we have examined the daily average returns for individual altcoins. This approach assumes that a miner already knows which altcoin to mine. Our next simulation departs from such an assumption, and it instead looks at a case where a miner randomly picks one of the 18 altcoins in **Table 1** and start mining on Day i. Again, $i = 1$ means the miner starts on the same day when a coin is listed on an exchange. The miner will stick to mining this altcoin for d days, devoting $1 of opportunity cost of mining every day, and selling all mined units at the end of each day. Since the miner picks a coin at random for each i, our goal is to compute the distribution of daily returns for these 18 coins for given i and d values.

First, suppose we set $d = 1$ day. The top chart in **Figure 1** shows the result of our new simulation. The x-axis shows the start day of mining, i (relative to the first day of listing at an exchange for each coin). The y-axis shows the distribution of daily average returns, r. The solid line represents the expected (i.e. mean) r for picking a random coin and starting to mine on Day i for $d = 1$ day. The band above and below the solid line indicates the standard deviation of r. For i between 0 and 57, a miner can randomly mine one of the 18 altcoins on Day i. At its peak, the mean r is $885.1 \pm 2,781.0\%$ on Day $i = 0$. The expected r value decreases over time. Between $i = 58$ and $i = 132$, the miner can only pick one of 17 altcoins, as we do not have the trading data for one

Table 2: A speculator that holds for 7 and 30 days. All units are in percentages unless otherwise specified.

	(a) 7 Days of Speculating					(b) 30 Days of Speculating				
Coin	*1st Day r*	$E(r)$	$\sigma(r)$	*P*	$T_{r<0}$ *(Days)*	*1st Day r*	$E(r)$	$\sigma(r)$	*P*	$T_{r<0}$ *(Days)*
ARG	10.72	-0.32	5.56	39.02	0	-0.48	-0.41	2.90	31.48	26
AUR	6.69	-0.22	5.87	41.38	0	3.39	-0.52	2.46	40.22	0
BTA	-26.24	0.35	6.87	47.31	11	-11.71	0.56	3.06	54.35	31
BTC	-1.97	0.44	2.51	55.17	6	-0.72	0.42	1.43	57.59	18
CURE	-3.74	-0.45	3.76	41.90	22	-6.30	-0.40	1.77	40.19	47
DGC	-5.33	0.00	4.44	41.26	10	-1.90	-0.06	2.21	37.04	10
DOGE	86.27	-0.06	4.53	39.06	0	5.24	-0.06	1.48	37.84	0
DOT	-17.47	-0.37	20.13	41.09	2	-18.67	-1.68	7.79	45.28	23
EFL	17.07	0.02	4.60	47.95	0	0.21	-0.18	2.06	47.83	0
HAM	-19.35	0.46	7.15	51.05	8	-1.12	0.35	2.35	64.24	1
LTC	-4.12	0.08	3.54	45.45	6	-0.34	0.05	1.63	39.55	6
PPC	-1.66	0.14	3.08	44.25	6	-0.16	0.11	1.60	46.99	3
RPC	-1.99	-1.13	4.89	39.08	1	-1.46	-1.25	2.24	28.50	88
SWING	1.61	-0.52	5.20	42.28	0	-1.04	-0.66	2.05	48.59	51
TROLL	-1.93	-0.69	4.38	51.92	1	-2.25	-0.16	1.22	51.72	13
UNO	3.34	-0.09	3.74	47.45	0	-2.08	-0.10	1.39	44.65	20
VCN	-43.26	0.80	7.99	58.97	5	-13.06	1.18	2.44	73.26	6
VIA	2.72	-0.21	3.53	44.74	0	1.49	-0.39	1.43	33.19	0
WBB	-20.82	0.17	5.77	41.97	22	-7.41	0.25	2.41	53.05	17
XJO	7.36	-0.82	3.37	35.68	0	-2.37	-0.86	1.58	29.90	25

of the altcoins beyond 57 days. In general, the mean of the expected r values between $i = 0$ and $i = 365$ is $21.2 \pm 79.4\%$ (i.e. the expected returns for a miner who picks a random coin on a random start day).

The middle and bottom charts in **Figure 1** show the results for $d = 7$ and 30 days. As d increases, the expected r and its standard deviation both decrease. Effectively, with lower expected returns, the risks are potentially lower, too. Furthermore, as d increases, a persistent pattern is that the returns tend to be higher when i is low, regardless of the d values. This implies that a miner who picks a random altcoin and mines it shortly after the altcoin is listed is likely to receive higher returns than later.

Speculating: In contrast to miners who acquire altcoins through mining, speculators acquire altcoins by buying from exchanges. Also, while miners mine and sell on the same day, speculators buy coins on one day and sell them later. We design similar simulations to measure the potential profitability for speculators. Specifically, we require that a speculator enter the market on a random day i, buy \$1 worth of coins, hold them the next $d - 1$ days, sell all the coins at the end of the d-day period for a total of v dollars. Again, we compute the average daily return by solving for r in this equation: $1 \cdot (1 + r)^d = v$.

Table 2 shows the results of our simulation. Similar to **Table 1**, **Table 2** shows the returns on the 1st Day, as well as the expected r values for $d = 7$ and 30 days. However, the trend is the opposite. Across the 18 altcoins, plus LTC and BTC, a speculator who enters the market on Day 1 receives *lower* returns than the average case for 12 of the coins for $d = 7$; for 30 days, we observe the same trend across 16 of the coins. In contrast to the $T_{r \geq 0}$ metric in **Table 1**, we compute $T_{r<0}$ here in **Table 2**, which counts the number of consecutive days since Day 1, such that if a speculator enters the market on one of these days for a given d value, she will receive $r < 0$. For instance, for $d = 7$

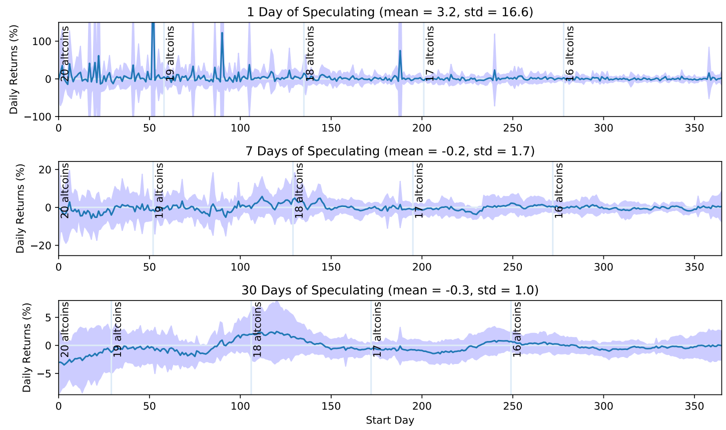

Fig. 2: Potential profitability of speculating a random coin.

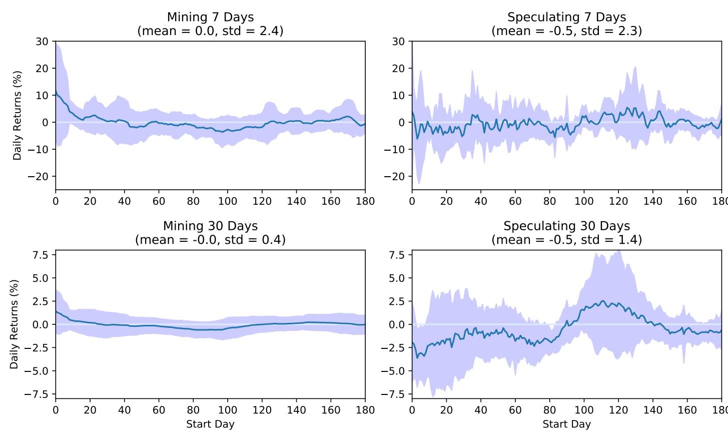

Fig. 3: Comparing the potential profitability of mining and speculating for the same set of 14 altcoins.

days, if a CURE speculator enters the market on any day between 1 and 22, she will receive negative returns; on Day 23, she will receive positive returns for the first time.

In addition to analyzing the returns for individual altcoins, we examine the case where a speculator picks an altcoin at random. **Figure 2** shows the result. Similar to **Figure 1**, **Figure 2** shows that as d increases from 1 Day, 7 Days, to 30 Days, the mean of the expected r values decreases, and so does the standard deviation; in other words, as the holding time increases, the potential returns and risks decrease. Contrary to **Figure 1**, **Figure 2** shows that a speculator who picks a random altcoin and enters the market soon after the altcoin is listed on exchanges is likely to receive *lower* returns than if she enters the market later.

To compare the returns between mining and speculating, we identify 14 out of the 18 coins, such that all of them can be involved in mining and speculation for $d = 7, 30$ days and $i = 0, \ldots, 180$ days. Again, we assume that an investor randomly picks one of the 14 coins on Day i, enters the market either by mining or buying, and exits d days later. We show the results in **Figure 3**. For both $d = 7$ and 30 days, if an investor who picks a random altcoin decides to enter the market early, her expected returns will be higher if she becomes a miner. For $d = 30$, if an investor decides to become a speculator, she can potentially receive higher returns in the best case (e.g. more than 6% around $i = 120$) than the best-case returns in mining (i.e. less than 5% at $i = 0$). However, the risk of speculation is also higher, as indicated by the larger standard deviation for the expected r value.

For more details on our findings, discussions of the results, and a description of the related work, refer to our technical report [7].

4 Conclusion

In this work, we compare the profitability of mining versus speculation for 18 altcoins. By comparing against BTC and LTC, we use opportunity cost to estimate the miners' effort in the 18 coins, and we design simulations to estimate the daily returns per $1 of investment, either through mining or speculating, under various conditions. These simulations show that a miner who starts mining shortly after an altcoin is listed can potentially earn higher returns than the average case, whereas a speculator who enters the market shortly after an altcoin is listed on exchanges might potentially earn lower returns. We also show that returns from mining a random altcoin tend to be lower with smaller standard deviations — less risky — than from speculation.

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