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Advances

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The Bitcoin Premium: A Persistent Puzzle

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Abstract: On average, stocks have a much higher rate of return than bonds; this has led to research on the *equity premium puzzle*. Similarly, Bitcoin outperforms stocks; I call this the *Bitcoin premium puzzle*. I show that standard macroeconomic models predict a low or negative Bitcoin premium. Though Bitcoin is extremely volatile, the model is rejected even when the coefficient of relative risk aversion is above 10. The Bitcoin premium declined after a structural break in late 2013. However, the puzzle is persistent; there has been no downward trend in the premium since.

Keywords: Bitcoin; stocks; asset-pricing puzzles

JEL Classification: G1; E2

1 Introduction

There is a large literature on the equity premium puzzle. While bonds are safer, the rewards of holding stocks tend to outweigh the risks. In this paper, I explore whether there is a Bitcoin premium puzzle. In its brief history, Bitcoin has already experienced a number of severe crashes. From 2010 to 2022, there are four times when it plunged by more than 75 %. However, on average it outperforms the stock market by a wide margin. Gains of 20 % in a single month aren't unusual. Is it too volatile for risk-averse investors? Or is that outweighed by the high rate of return?

I investigate using three different methods that are common in the equity premium literature. First, I calculate the model's Bitcoin premium (i.e. $E[R^{bitcoin} - R^{stocks}]$). Mehra and Prescott (1985) took this approach and many papers followed them (e.g. Barro 2006; Cogley 2002; Rietz 1988). However, stocks are more tightly

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correlated with consumption, so the model tends to predict a very low Bitcoin premium. Next, I test the Euler equation (Brav, Constantinides, and Geczy 2002; Kocherlakota 1996; Wilson 2020). Due to the volatility, the confidence intervals are very wide. However, the model is still rejected anyways. Lastly, I use GMM to estimate the coefficient of relative risk aversion (Grossman, Angelo, and Shiller 1987; Jacobs 1999; Kocherlakota and Pistaferri 2009; Toda and Walsh 2015). However, in this case the power of the test is extremely low.

Overall, there is a puzzle if the whole sample is used. This is largely driven by the early years, when Bitcoin sometimes doubled in a single month. I find a structural break in late 2013, consistent with Ciaian, Rajcaniova, and Kancs (2016), Bouri, Azzi, and Dyhrberg (2017), and Dastgir et al. (2019). However, there is still a puzzle after the break and it is not shrinking over time.

This paper adds to the long list of asset-pricing anomalies. In addition to the equity premium puzzle, there is also the risk-free rate puzzle (Weil 1989) and the excess volatility puzzle (Shiller 1981). Gabaix (2012) discusses several other asset-pricing puzzles. They arise from standard economic models. If we cannot solve these puzzles, then the foundations of economics are called into question. While I briefly discuss potential solutions to the Bitcoin premium puzzle, my main focus is on documenting a new anomaly and its robustness.

2 Cryptocurrency Literature

There is a rapidly growing literature on cryptocurrency. I will focus on the economics; for a discussion of the blockchain technology and its literature, see John, O'Hara, and Saleh (2022). Most of the economic research is empirical, though there are a few theoretical papers. Choi and Rocheteau (2021) introduce a search model in which agents engage in costly mining of private currency. Once enough people are holding the currency, it is used in transactions. Schilling and Uhlig (2019) study an endowment economy and provide conditions for when Bitcoin speculation will occur. They stress that Bitcoin can still be used as a medium of exchange even when there is volatility in its price.

The empirical literature is full of disagreements. Cheah and Fry (2015) and Cheung, Roca, and Su (2015) find evidence of speculative bubbles. The price of Bitcoin soared in 2013 before crashing, but Blau (2017) does not detect a speculative bubble. Corbet, Brian Lucey, and Yarovaya (2018) and Chaim and Laurini (2019) both find bubbles in 2013 but not in the 2017 rally. Geuder, Kinateder, and Wagner (2019) also finds no bubble in 2017, but Fry (2018) does. Gandal et al. (2018) and Griffin and Amin (2020) argue that there was price manipulation in 2013 and 2017, respectively.

The efficient market hypothesis has attracted a lot of attention. However, the literature in this area is also mixed. El Alaoui, Bouri, and Roubaud (2019) rejects market efficiency. Urquhart (2016) also rejects it, but Nadarajah and Chu (2017) reanalyze the same data and reach the opposite conclusion. Bariviera (2017) finds that the market was efficient after 2013 but not before. Kayal and Balasubramanian (2021) report that volatility has been declining over time and that the market is approaching efficiency. However, Jiang, He, and Ruan (2018) argues that the market remains inefficient. Within this literature, some papers focus on a specific form of inefficiency. E.g., Urquhart (2017) shows evidence that price clusters at round numbers. Borri and Shakhnov (2022) and Makarov and Schoar (2020) examine whether traders can arbitrage Bitcoin by buying and selling on different exchanges. Trading volume can be used to predict returns under certain conditions (Balcilar et al. 2017; Bouri et al. 2019). However, Aalborg, Molnár, and Erik de Vries (2019) disagrees. Bouri et al. (2019) finds that volume can be used for predicting returns for some cryptocurrencies, but not Bitcoin. Many papers find that social media sentiment influences the price of Bitcoin (Dastgir et al. 2019; Garcia and Schweitzer 2015; Kim et al. 2016; Kim et al. 2017; Polasik et al. 2015). If the market is inefficient, then the Bitcoin premium puzzle would deepen. I use monthly data and only consider buy-and-hold. I conclude that the excess returns on Bitcoin are too large for the model to explain. That result would strengthen if market inefficiency allows investors to earn an even higher return on Bitcoin.

There is research on whether Bitcoin can be a hedge against risk in financial markets. Briere, Oosterlinck, and Szafarz (2015), Dyhrberg (2016), and Borri (2019) find a weak correlation between Bitcoin and other assets, so Bitcoin is good for hedging. However, Conlon and McGee (2020) disagree, since in their dataset there is a strong correlation between stocks and Bitcoin. These different conclusions might be due to the sample; Conlon and McGee (2020) use more recent data. As I show in the next section, the correlation between stocks and Bitcoin has been tightening over time. However, Fang et al. (2019) argues that Bitcoin's hedging properties depend on economic policy uncertainty. Chan, Le, and Wu (2019) finds that Bitcoin is a good hedge when examining monthly returns but not for weekly or daily returns. However, none of these papers consider whether there is an asset-pricing puzzle.

Several papers develop and test asset-pricing models. Factor models are a popular approach (e.g. Borri et al. 2022; Liu and Tsyvinski 2021; Liu, Tsyvinski, and Wu 2022; Li and Yi 2019). However, there is hardly any research using the standard macro framework. The only paper seems to be Borri and de Magistris (2021). Their definition of excess returns compares cryptocurrency and bonds. Dunbar and Owusu-Amoako (2022) calculate excess returns in the same way, though they use a CAPM. However, I am focused on comparing Bitcoin and stocks. From the equity premium puzzle, we already know that bonds underperform, even after accounting for the higher risk in the stock market. None of the papers study if there is a Bitcoin premium puzzle.

3 Data

I use monthly data from April 2010[1] to February 2023. The Bitcoin data comes from TradingView's all-time history index. For US stocks, I use Vanguard's Total Market index fund (VTI). It is adjusted for dividends. For US consumption, I use the PCE for nondurables and services.[2] Following the literature, I exclude durables. This is because durable expenditures are a poor proxy for durable consumption. Buying a dishwasher is a one-time surge in spending, but consumption lasts for years. Services and non-durables (e.g. groceries) will probably be consumed in the same month that they are purchased. Thus, spending reflects consumption. I use the PCE deflator to adjust for inflation.

First, I work with the entire sample. I will show later that there is a structural break in December 2013, so then I will restrict the sample to December 2013–February 2023. Figure 1 plots the real gross rates of return. The stock market plunged during the pandemic, but that is dwarfed by the massive swings in Bitcoin. There are a few months in which Bitcoin more than doubled. Typically, Bitcoin has a higher rate of return. However, in the more recent data, the gains seem to be smaller. This suggests that the Bitcoin premium might be a smaller puzzle at the end of the sample.

The correlation between stocks and Bitcoin has been tightening. This is shown in Figure 2, which uses rolling four-year windows.

4 Results

4.1 Theoretical Model

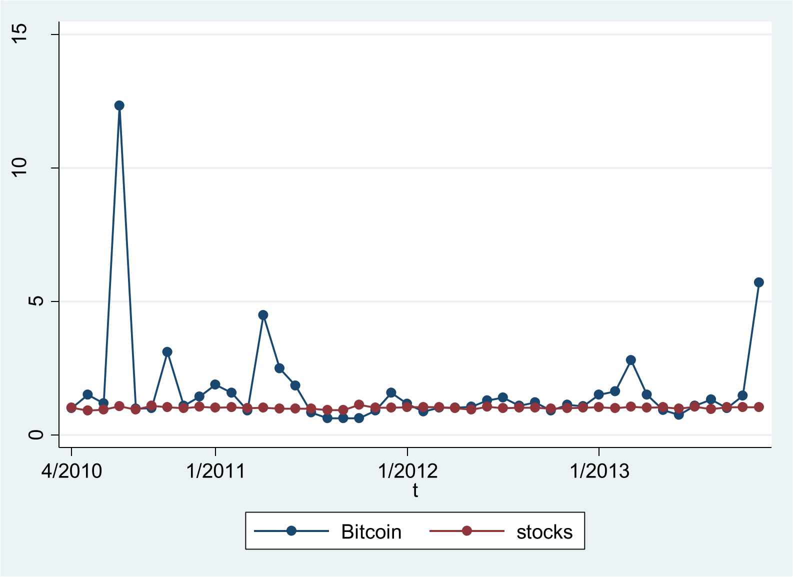
Assuming CRRA utility, the Euler equations are

$$c_t^{-\alpha} = \beta E_t\left[R_{t+1}^{bitcoin} c_{t+1}^{-\alpha}\right] \tag{1}$$

1 The first Bitcoin exchange was set up on March 17, 2010 (Guinness World Records 2022), so April 2010 would be first full month.

2 This is constructed by subtracting the PCE for durables (Series PCEDGC96 in the St. Louis FRED) from the overall PCE (Series PCEC96). I adjust for inflation using Series PCEPI in the St. Louis FRED. Later, I also use monthly Treasury bond data; this comes from Series GS1M in the St. Louis FRED.

Panel A: April 2010-November 2013. $N = 44$



Panel B: December 2013-February 2023. $N = 110$

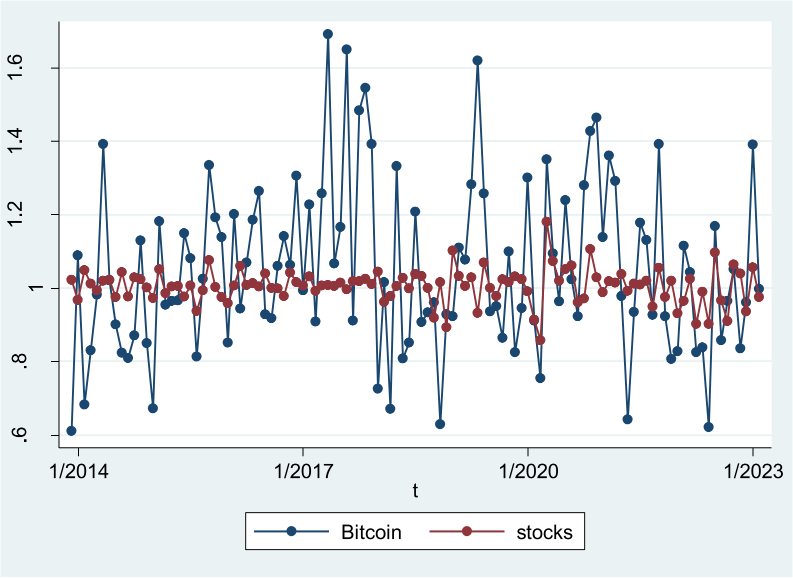


Figure 1: Monthly gross rates of return on Bitcoin and stocks. Panel A: April 2010–November 2013. $N = 44$. Panel B: December 2013–February 2023. $N = 110$.

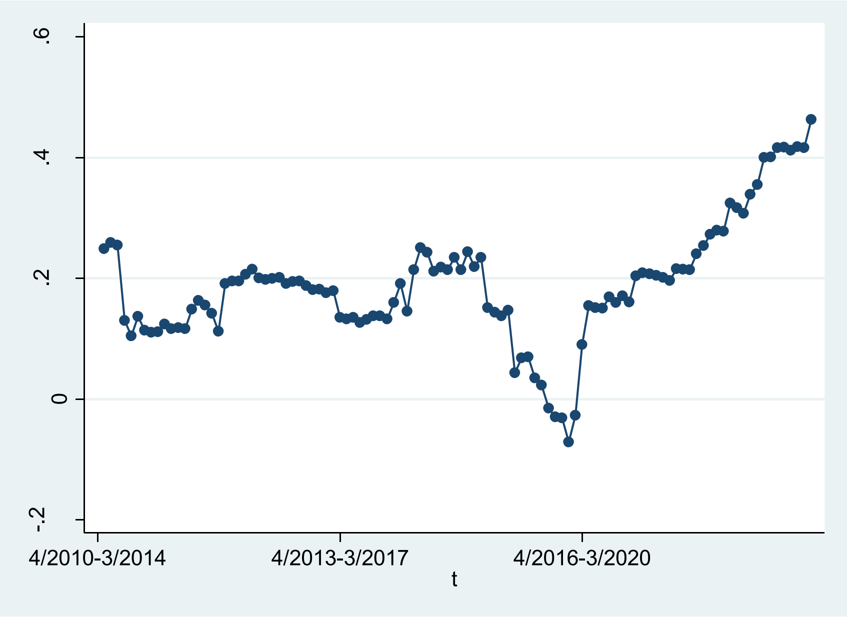


Figure 2: Correlation coefficient for the monthly gross rates of return on stocks and Bitcoin. $N = 154$.

$$c_t^{-\alpha} = \beta E_t\left[R_{t+1}^{stocks} c_{t+1}^{-\alpha}\right] \tag{2}$$

Here $R_t^{bitcoin}$ and R_t^{stocks} are the gross rates of return on Bitcoin and stocks, respectively. The coefficient of relative risk aversion is α. The discount factor is β. Consumption is c_t. I use aggregate consumption rather than household consumption. It is well known that this substitution is justified if markets are complete (e.g. Wilson 2020). After applying the Law of Iterated Expectations, the model can be rewritten as in Equation (4).

$$R_t^{excess} = R_t^{bitcoin} - R_t^{stocks} \tag{3}$$

$$E\left[\left(R_{t+1}^{excess}\right)\left(c_{t+1}/c_t\right)^{-\alpha}\right] = 0 \tag{4}$$

I split up Equation (4) in order to isolate the Bitcoin premium, which is in Equation (6).

$$E\left[\left(R_{t+1}^{excess}\right)\right]E\left[\left(c_{t+1}/c_t\right)^{-\alpha}\right] + Cov\left(R_{t+1}^{excess}, \left(c_{t+1}/c_t\right)^{-\alpha}\right) = 0 \tag{5}$$

$$E\left[R_{t+1}^{excess}\right] = -\frac{Cov\left(R_{t+1}^{excess}, \left(c_{t+1}/c_t\right)^{-\alpha}\right)}{E\left[\left(c_{t+1}/c_t\right)^{-\alpha}\right]} \tag{6}$$

4.2 Results in the Full Sample

First, I calculate the model's Bitcoin premium. This is done by calculating the sample covariance in Equation (6) as well as the sample mean of the marginal utility ratio. These values are plugged into the right hand side of Equation (6). Then I compare it to the sample mean of R_{t+1}^{excess} in the data. For comparison, I also show the results for the equity premium in Table 1. My sample includes the pandemic, and there is literature on how disaster states can resolve the equity premium puzzle (e.g. Barro 2006; Rietz 1988). Thus, the model does unusually well with explaining the equity premium. The predicted excess returns are within the 95 % confidence interval when the CRRA parameter is as low as six.

Thus, the choice of sample period would tend to bias us against finding a Bitcoin premium puzzle. Due to the volatility of Bitcoin, the confidence interval is very wide, which would also bias us against rejecting the model. Nevertheless, there is still a puzzle. If the coefficient of relative risk aversion is 66, the model predicts a Bitcoin premium of 6.03 % per month, which is barely within the 95 % confidence interval.

Before the pandemic, the correlation between stocks and marginal utility tended to be negative. This is shown in Figure 3 with rolling four-year windows. Thus, stocks do not provide insurance against shocks. If an agent tries to smooth consumption by withdrawing from savings, then their stocks have probably fallen.

Table 1: The monthly Bitcoin premium in the model and the data, April 2010 – February 2023. $N = 154$.

CRRA parameter (α)	Model's predicted $R_t^{Bitcoin} - R_t^{stocks}$	Model's predicted $R_t^{stocks} - R_t^{bonds}$
1	0.0000	0.0001
6	0.0004	0.0007
11	0.0016	0.0022
16	0.0039	0.0053
21	0.0077	0.0113
26	0.0135	0.0219
31	0.0215	0.0386
36	0.0313	0.0615
41	0.0411	0.0879
46	0.0494	0.1129
51	0.0550	0.1329
56	0.0582	0.1468
61	0.0598	0.1556
66	0.0603	0.1610
R_t^{excess} in the data:	0.2280 ± 0.1679	0.0077 ± 0.0071

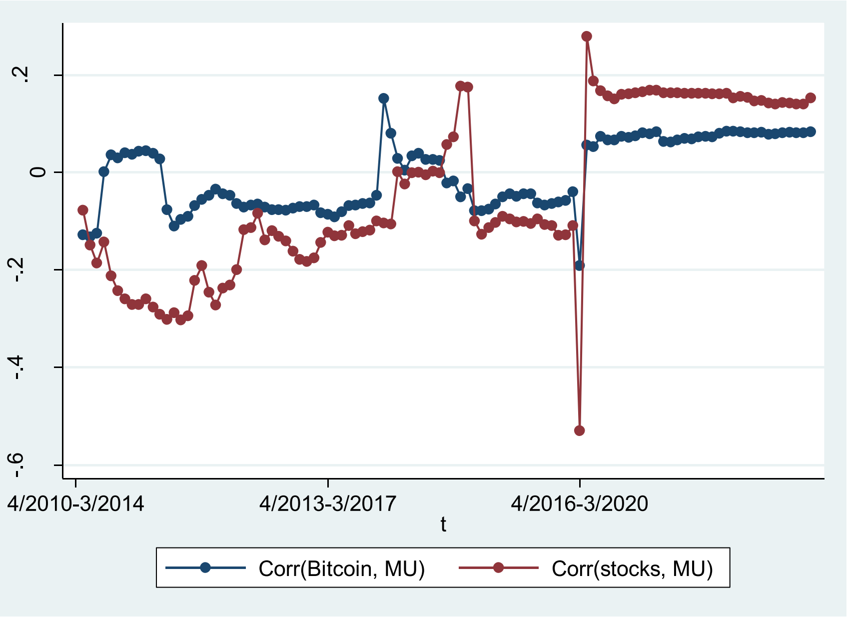


Figure 3: Correlation between monthly gross rates of return and marginal utility. The coefficient of relative risk aversion is set equal to one. $N = 154$.

On the other hand, the correlation between Bitcoin and marginal utility is closer to zero. This means that Bitcoin is slightly better at providing insurance. According to the model, there should be a tradeoff: if one asset is better insurance, then it should have a lower rate of return. Otherwise people would not buy the other asset. After the pandemic, stocks began providing better insurance than Bitcoin, but the difference is small. This is why the model fails to explain the large Bitcoin premium.

In the second test, I check the Euler equation, which can be rewritten as follows. The forecast error is f_{t+1}; its sample mean should not be significantly different from zero. The results are in Table 2. The model is rejected for all reasonable levels of risk aversion.

$$E\left[\left(R_{t+1}^{excess}\right)\left(c_{t+1}/c_t\right)^{-\alpha}\right] = \left(R_{t+1}^{excess}\right)\left(c_{t+1}/c_t\right)^{-\alpha} - f_{t+1} = 0, \quad E\left[f_{t+1}\right] = 0 \qquad (7)$$

The mean is always positive and significant. i.e., the expected marginal utility is higher if agents hold Bitcoin instead of stocks. Thus, people should be buying more Bitcoin and fewer stocks.

Table 2: Test of Equation (7). The model predicts that the mean of the forecast error is zero. Sample period: April 2010 – February 2023. $N = 154$.

Coefficient of relative risk aversion (α)	Sample mean	*P*-value
1	0.2277	0.008
6	0.2264	0.008
11	0.2260	0.007
16	0.2275	0.006
21	0.2324	0.005
26	0.2438	0.005
31	0.2675	0.006
36	0.3147	0.018
41	0.4063	0.061

In the third test, I use GMM to estimate the coefficient of relative risk aversion in Equation (4). The results are in Table 3. In the first column, I do not use any instruments other than the constant. There is only one parameter to estimate, so in this case it is exactly identified. The standard error is extremely large; this is due to the volatility of Bitcoin. In the other columns, I use lags as instruments. The standard error is lower, but it is still very high. In all cases, the overidentifying restrictions are rejected. The GMM test has almost no power, so I do not use it in the rest of my results.

4.3 Structural Break

Overall, there is a Bitcoin premium puzzle in the full sample. However, it is mostly driven by the earlier years. In Figure 1, we saw that Bitcoin's highest returns were

Table 3: GMM estimation of the coefficient of relative risk aversion. Sample period: April 2010 – February 2023. $N = 154$.

CRRA parameter (α)				
Mean	9.8112	−2.0448	11.8595	−0.9727
Standard error	3,695,525	28.5723	149.8652	22.2594
Instruments:				
Lag of c_{t+1}/c_t	No	Yes	No	Yes
Lag of R_t^{excess}	No	No	Yes	Yes
P-value from test of overidentifying restrictions:	–	0.0058	0.0058	0.0181

before 2014. There is a structural break in R_t^{excess} in December 2013 (supremum of the F statistics = 12.74, p-value = 0.0073). The same is true for the Euler equation test. For all values of the CRRA parameter α, the supremum of the F statistics was greater than 12, and the p-value was less than 0.01. I reran the tests for the sample period of December 2013–February 2023. However, Bitcoin was still obscure in December 2013. I also considered May 2017–February 2023, when Bitcoin became more popular. This subsample was chosen since there is a structural break in trading volume in May 2017 (supremum of the F statistics = 18.32, p-value = 0.0005).

Table 4 shows the Euler equation tests. The sample mean of the forecast errors is positive and significant. However, it is much smaller than in the full sample (Table 2).

Table 5 calculates the model's Bitcoin premium. After the structural break, the average monthly R_t^{excess} is about 4 %, compared to 23 % in the whole sample. While the confidence interval is wide, the mean of R_t^{excess} remains significantly greater than zero. In this period, $Corr(MU, R^{stocks})$ and $Corr(MU, R^{bitcoin})$ are about equal (see Figure 3). Therefore, the model predicts a Bitcoin premium that is close to zero.

Table 4: Test of Equation (7). The model predicts that the mean of the forecast error is zero. $N = 110$.

CRRA parameter (α)	Dec 2013–Feb 2023		May 2017–Feb 2023	
	Sample mean	P-value	Sample mean	P-value
1	0.0439	0.039	0.0625	0.033
6	0.0446	0.036	0.0635	0.031
11	0.0466	0.032	0.0666	0.028
16	0.0510	0.032	0.0736	0.031
21	0.0603	0.046	0.0881	0.051
26	0.0785	0.092	0.1169	0.106

Table 5: The monthly Bitcoin premium. $N = 110$.

CRRA parameter (α)	Dec 2013–Feb 2023	May 2017–Feb 2023
	Model's predicted R_t^{excess}	Model's predicted R_t^{excess}
1	−0.0001	−0.0001
6	−0.0009	−0.0010
11	−0.0026	−0.0029
16	−0.0058	−0.0135
R_t^{excess} in the data:	0.0439 ± 0.0417	0.0625 ± 0.0475

Table 6: Regression with dependent variable R_t^{excess}. Sample: December 2013–February 2023. $N = 110$.

	Coefficient	***P*-value**
T	0.0004	0.561
Constant	0.0055	0.937

Since the puzzle is smaller in this sample, perhaps it is shrinking over time and will eventually disappear. To investigate this, I regressed R_t^{excess} on a time trend. If the puzzle is shrinking, then the time trend will be negative. However, Table 6 shows that the trend is positive, though it is statistically insignificant. The puzzle is not going away.

5 Conclusions

Many have been skeptical of Bitcoin; its extraordinary growth seems unsustainable. Excess returns fell after the structural break in late 2013, but they remain positive and significant. In this period, the Bitcoin premium stopped declining. Bitcoin is extremely volatile, but the model is still rejected even if the coefficient of relative risk aversion is high.

Further research could study alternative cryptocurrencies (or “altcoins”). Ethereum has often outperformed Bitcoin; perhaps there is an Ethereum premium puzzle. I chose to focus on Bitcoin due to survivorship bias. Many altcoins have failed (e.g. Luna). If the sample only includes altcoins that have withstood the test of time, then the results will be biased in favor of finding a puzzle. An additional challenge is that many altcoins were created very recently, so there is not much data. In the equity premium literature, several papers have attempted to correct for survivorship bias, e.g. Li and Xu (2002) and Brown, Goetzmann, and Ross (1995).

There have been many attempts to solve the equity premium puzzle. However, not all of these approaches are likely to succeed for the Bitcoin premium puzzle. Kocherlakota (1996) demonstrates that transaction costs are too small to explain the equity premium puzzle. The same is almost certainly true for Bitcoin. Fees are well below 1 % on many cryptocurrency exchanges. In the equity premium literature, a number of papers consider “disaster states” (Barro 2006; Gabaix 2012; Rietz 1988). Though there might not have been any disasters in the historical data, there is a chance that one might occur in the future, so stocks are riskier than they appear. However, Bitcoin has already suffered from many crashes. Its historical data already reflects the risk of a disaster. There are several models of incomplete markets and equity premium (Cogley 2002; Jacobs 1999; Kocherlakota and Pistaferri 2009). In these papers, the authors show that there is no representative agent. Therefore, they rely on household consumption data instead of aggregate consumption. Even after correcting for the measurement error in the household surveys, consumption remains very volatile (Wilson 2020). For the Bitcoin premium puzzle, if both consumption and the rate of return fluctuate wildly, then the confidence intervals will be extremely wide and the tests will lack power. Constantinides and Darrell (1996) introduce an incomplete markets model in which agents face idiosyncratic shocks, but it does not rely on potentially mismeasured household consumption.

This paper presents a new asset-pricing puzzle. Finding a solution will be challenging.

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