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AN INVESTIGATION OF THE PRESENCE OF ANOMALIES IN DIGITAL ASSET MARKETS: THE CASE OF BITCOIN

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Abstract

This paper examines the cryptocurrency Bitcoin to determine if there is evidence of the weekday effects, such as the Monday effect, during the period between 2 January 2011, and 10 September 2019. The study shows that Bitcoin exhibits a Monday effect at the 10% level of significance and a Tuesday and Sunday effect at the 1% significance level. The S&P 500 stock index also showed a Monday effect but did not exhibit a Tuesday or Sunday effect. The study also examined if there was a Month of the Year effect and found that Bitcoin exhibited a May and November effect at the 10% significance level.

Keywords: Anomalies, EMH, Seasonality, Bitcoin, Cryptocurrency

JEL: G11, G12, G14, G17

1. Introduction

Since the Efficient Market Hypothesis (EMH) was first introduced (Fama, 1970), there has been a significant amount of research focused on the validation of as well as challenging the basic premise of this theory. Many studies have focused on the existence of market anomalies, which are a key challenge to the EMH. Market anomalies suggest that the market is not as efficient as suggested by the EMH. While there has been extensive research conducted on equity markets, national currencies and other financial instruments, there is a need to develop further insight into emerging instruments such as cryptocurrencies to determine if these markets have matured and are operating efficiently. This study examines seasonality in cryptocurrencies, specifically focusing on daily and monthly anomalies that are present in Bitcoin from January 2011 through September 2019. Bitcoin was created on 3 January 2009, as an entirely digital cryptocurrency that is free of a central bank or single administrator (Nakamoto, 2008). While not the only cryptocurrency in circulation, Bitcoin serves as the most prominent representative of this market both in terms of trading volume and acceptance as a means of payment around the globe. As Bitcoin has continued to mature over the past decade, it is critical that we attain further insight into its efficiency in the market and performance in relation to other established currencies such as the USD.

The remainder of this paper is organized as follows: Section 2 provides the review of pertinent academic literature, Section 3 details the data set and methodology utilized in this study, Section 4 reports the empirical results, and finally, Section 5 provides a summary of the paper content and the conclusion.

2. Literature Review

Market seasonality, which includes various aspects of market anomalies, such as the weekend effect, Monday effect, and day-of-the-week effect, has been thoroughly studied since the 1970s, with the initial focus on equities markets. In studies conducted by Cross (1973), French (1980), and Gibbons and Hess (1981) there have been documented market anomalies, such as the Monday effect in equity markets, with each study providing evidence to support lower market returns on Mondays than on the other days of the week. Further studies have been performed to examine if the Monday effect could also be detected in other markets, such as the foreign exchange market. Yu, Chiou, and Jordan-Wagner (2008), for example, studied the effect in the Yen, British Pound, and USD. The authors did not find evidence to support a noticeable Monday effect in the period studied; however, they did find that Tuesdays seem to exhibit the largest increase in exchange rates for the week. It is notable that the period of analysis in their study, which dates 1994 through 2003, coincided with a relatively healthy economy, which may explain the lack of a Monday downturn in the currency markets of the time.

In further studies, Arsad and Coutts (1996) discovered a statistically significant Monday effect when there was negative news in the stock market based on the Financial Times Industrial Ordinary Shares Index of the London International Stock Exchange. The study covered an extended period from 1935 through 1994, which was broken into 12 equal periods over the 60 years examined. The authors observed that the downturn on Mondays was significant when there was negative market news present, defined by an overall downturn in the stock market, and inconsistent when there was positive news, defined by an overall upturn in the stock market. Patell and Wolfson (1982) and Penman (1987) also provided validity to the negative news argument, concluding that positive news tends to occur during trading hours, while negative news tends to occur after hours and on weekends, leading to more downturns on Mondays.

As suggested in the findings of Yu, Chiou, and Jordan-Wagner (2008), studies often find evidence of time or day-of-the-week effect in currency markets for days other than Monday. Thatcher and Blenman (2001) studied the USD/GBP market and saw a drop in exchange rates on Wednesdays. Their work is supported by earlier studies conducted by Goodhart and Figlioli (1991), and Lyons (1995), who reported a time-of-the-day effect in intra-day trading. Levi (1978), Bossaerts and Hillion (1991) and Bessembinder (1992) all found a day-of-the-week effect in various currency markets. Some of the conclusions of these studies attribute the effects to asymmetries in bid-ask spreads, measurement errors, and new information arrival. No study to date has been able to define the reason for the day-of-the-week-effect definitively, and as such, it is plausible that all the proposed explanations contribute in part to the effect. McFarland, Pettit, and Sung (1982) conducted a study on eleven foreign currency pairs and found that dollar-denominated price changes are significant on Mondays and Wednesdays and low on Thursdays and Fridays for all eleven currencies being traded.

Connolly (1989) found that the day-of-the-week effect tends to be inconsistent over time. Research provides evidence that the impact can be measurable in one period, and then no longer present in another period. The effect also tends to reverse itself at times, becoming negative on Friday and positive on Monday, as was highlighted in a study conducted by Brusa, Liu, and Schulman (2000). In another study, Kamara (1997) found that the effect seems to have diminished in U.S. equity markets with the introduction of the S&P 500 futures contract.

While there has been a substantial amount of research conducted regarding market seasonality in equity and standard currency markets, there has been minimal focus on cryptocurrency markets as they have evolved into mainstream products. One of the first studies of the cryptocurrency market to test for market efficiency was conducted by Urquhart (2016), which provided one of the first insights into the market efficiency of Bitcoin and

concludes that Bitcoin returns do not provide evidence to support that it is weak-form efficient. In 2017, Nadarajah and Chu ran multiple tests and concluded that Bitcoin is largely weak form efficient over their estimation period. Also, in 2017, Kurihara and Fukushima examined Bitcoin for weekly price anomalies, with the results showing that the Bitcoin market is not efficient.

Early studies of the cryptocurrency markets, and more specifically of Bitcoin, were focused on the general efficiency of the market as these currencies have begun to mature over time. More recent studies have focused directly on market anomalies to determine whether specific evidence can be found to both support and explain the inefficiencies noted in earlier studies. In 2018, Hattori and Ishida tested for arbitrage activities by investors in the Bitcoin futures market and reported findings that support the existence of market efficiency. Aharon and Qadan (2018) studied Bitcoin from 2010 to 2017 and provide initial evidence about the existence of the day-of-the-week effect anomaly not only in returns but also in volatility. Further evidence is provided by Caporale and Plastun (2018). They studied the day-of-the-week effect of cryptocurrency markets using several techniques. They found that Bitcoin exhibits a reverse Monday effect with Monday returns being significantly higher than other days of the week. This finding is further supported by Ma and Tanizaki (2019), who also find that Bitcoin has a higher mean return and volatility on Monday than other days of the week. In another study, Fraz, Hassan, and Chughtai find evidence of higher returns on Monday than on other days of the week, further supporting the potential existence of the reverse Monday effect.

The purpose of this paper is to determine if there are day-of-the-week and month-of-the-year effects in cryptocurrency markets, specifically Bitcoin, from July 2010 through September 2019. We will employ the same statistical procedures developed by Connolly (1989) as the basis for this analysis to evaluate our theory.

3. Data and Methodology

3.1 Data

The data of this study covers daily closing values of Bitcoin and the S&P 500 from 2 January 2011 to 10 September 2019. To collect the data, we select January 2011 as the starting date, which is two years after the introduction of Bitcoin to provide the market with sufficient time to become familiar and to adjust with the trading of digital currency and new assets.

To explore the presence of an anomaly in the Bitcoin market, we examine both the-day-of-the-week and the-month-of-the-year effect to shed light on the behaviour of these markets in the context of market efficiency.

3.2 Methodology

We define the daily changes in the daily closing value of Bitcoin and the S&P 500 as:

$$Rt = \ln (Pt/Pt\text{-}1) * 100 \qquad (1)$$

where: Rt is the daily log return, Pt is the closing value of the Bitcoin and S&P 500 index on day t, and Pt-1 is the closing value of the Bitcoin and S&P 500 index on day t-1.

We perform an Augmented Dickey-Fuller to test for stationarity of the time- series used, and the results indicate that the calculated daily changes are stationary of the first order. The results are not presented here to conserve space but are available from the authors upon the request.

In line with the commonly used methodology in the finance literature (for instance, see Bush and Stephens, 2016), we use the following regression models to examine the presence of the day-of-the-week and the month-of-the year effects in series used:

For the day-of-the-week effect, we employ the following regression:

$$Rt = \alpha 1D1 + \alpha 2D2 + \alpha 3D3 + \alpha 4D4 + \alpha 5D5 + ut \quad (2\text{-}1)$$

$$Rt = \alpha 1D1 + \alpha 2D2 + \alpha 3D3 + \alpha 4D4 + \alpha 5D5 + \alpha 6D6 + \alpha 7D7 + ut \quad (2\text{-}2)$$

where Rt is the daily change of Bitcoin or daily return of the S&P 500 and D1 – D5 are dummy variables for the five days of the week. It follows that if t is a Monday, then D1 = 1 otherwise D1 = 0, if t is a Tuesday, then D2 = 1 otherwise D2 = 0, if t is a Wednesday, then D3 = 1 otherwise D3 = 0, and so forth. We use model 2-1 for S&P 500(with five-day trading per week and Model 2-2 for Bitcoin (with seven-day trading per week). The as are coefficients to be estimated and ut. is a random error term. If the estimated coefficient a 1, in 2-1, is statistically significantly negative for Bitcoin and S&P 500, then the results imply the presence of a traditional Monday effect.

For month-of-the-year effect, we estimate the following model:

$$Rt = \alpha 1D1 + \alpha 2D2 + \alpha 3D3 + \alpha 4D4 + \alpha 5D5 + \alpha 6D6 + \alpha 7D7 + \alpha 8D8 + \alpha 9D9 + \alpha 10D10 + \alpha 11D11 + \alpha 12D12 + ut \quad (3)$$

where Rt is the daily return in day t, as defined earlier; a s are coefficients to be estimated; Ds are dummy variables for the twelve months of the year, such that dummy variable takes the value of 1 in January and zero in the other month of the year, dummy variable takes the value of 1 in February and zero in the other month of the year, and so on. Finally, ut is a random error term.

4. Empirical Results

The empirical findings of the analysis suggest statistically significant positive returns in the Bitcoin market on Monday, which is consistent with Perry and Mehdian (2001), as a reversal of the traditional Monday effect. The findings also suggest that there are significant positive returns in the Bitcoin market in April, May, and November. The results of the Bitcoin analysis have been compared to the S&P 500 index as a base as the S&P 500 index is widely considered efficient in order to provide further perspective to support the findings. As such, the research shows a positive return on Monday for the S&P 500 index, which is likely driven by the bull run that has been present in U.S. equity markets since the end of the 2008 recession. The means and standard deviations, in parentheses, of the weekly and monthly series, are displayed in tables 1 and 2. As can be seen from Table 1, daily mean and volatility measured by standard deviation are significantly higher for Bitcoin compared to the S&P 500 in all days of the week. In addition, the same conclusion is observed in the case of monthly data, where the monthly standard deviation of Bitcoin is higher compared to the S&P 500 over all months of the year. It is notably that the volatility in the Bitcoin market is substantially higher in January, August, and September than during the other months of the year. It is also important to note that Bitcoin has a negative average return during June, July, August, and September, which is notable as these average negative returns occurred with the backdrop of a U.S. equity market bull run in play. Both of these findings would suggest that further research should be conducted to assess these specific results in more detail.

Table 1: Daily Summary Statistics (in daily percent change) for S&P and Bitcoin

Day	S&P	Bitcoin
Monday	0.11905723 *(0.89772784)*	0.65157367 *(5.68301653)*
Tuesday	0.01818258 *(0.90582155)*	0.61008925 *(8.72744464)*
Wednesday	0.03882869 *(0.90747814)*	0.22944375 *(5.67211905)*
Thursday	0.03096718 *(0.94233403)*	0.26897888 *(5.26948043)*
Friday	0.0103063 *(0.9485828)*	0.40384325 *(6.20264308)*
Saturday	-	0.21629026 *(4.38435922)*
Sunday	-	0.4718197 *(5.51850004)*

Table 2: Monthly Summary Statistics (in daily percent change) for S&P and Bitcoin

Month	S&P	Bitcoin
January	-0.0615281 *(1.37885433)*	2.78831672 *(9.53640299)*
February	0.02828287 *(1.25329554)*	1.34286649 *(5.40096028)*
March	0.09324123 *(0.81058649)*	0.91149278 *(4.79714111)*
April	0.07734207 *(0.71501794)*	0.55113005 *(4.54934694)*
May	0.04900005 *(0.63792663)*	0.18622891 *(4.57377319)*
June	0.03498444 *(0.80597085)*	-0.18426177 *(4.74695729)*
July	-0.0175688 *(1.15686775)*	-0.64311727 *(5.22736441)*
August	0.03498444 *(0.80597085)*	-1.50261287 *(7.0547035)*
September	0.05631579 *(0.44725544)*	-1.1612101 *(9.46684975)*
October	0.05163683 *(0.88646837)*	0.38990625 *(2.71853763)*
November	-0.0241971 *(1.07231335)*	0.2465542 *(2.71722759)*
December	0.07396224 *(0.80347047)*	0.08277347 *(2.76843245)*

The results provided in Table 3 contain the estimated coefficients and corresponding statistics from the estimation using the data pertaining to the day of the week effect analysis. For the S&P 500 index, we can see a statistically significant reverse Monday effect 1% level of

significance as the Monday effect would be distinguished by a negative average return for this day of the week. Similarly, Bitcoin also exhibits a reverse Monday effect at the 1% level, however in contrast we see a positive return on Tuesday and Sunday that is significant at the 10% level.

Table 3: Regression of Day-of-the-week effect in the S&P and Bitcoin

Index	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
S&P	0.11844787 (2.62669853)***	0.0192521 (0.44673131)	0.05360717 (1.24391651)	0.02695893 (0.6206783)	-0.0183365 (0.4216874)	-	-
Bitcoin	0.65303137 (2.15849235) ***	0.53558821 (1.77030246)*	0.04157198 (0.13725822)	0.20890139 (0.68972977)	0.29444668 (0.97217467)	0.13378185 (0.44219484)	0.43002701 (1.42138654) *

Notes: T-Statistic is given in parentheses *** significant at 1 percent and *significant at 10 percent

The results provided in Table 4 contain the estimated coefficients and corresponding statistics from the estimation using the data pertaining to the month of the year effect analysis. The results provide evidence to show that Bitcoin displays positive returns that have statistical significance at the 1% level in April, May and November. As a means of comparison, the S&P 500 index does not provide return results in any month that have an appropriate level of statistical significance.

Table 4: Regression of Month-of-the-year effect in the S&P and Bitcoin

Month	S&P	Bitcoin
January	-0.0615281 (-0.9090758)	0.20077538 (0.52035122)
February	0.067882 (0.9751663)	0.33506945 (0.82858242)
March	0.10329564 (1.57543421)	0.04639244 (0.12023567)
April	0.07734207 (1.1520551)	0.86883152 (2.2151415) ***
May	0.04900005 (0.74349179)	0.92824394 (2.40573756) ***
June	0.03498444 (0.52807136)	0.26924533 (0.68645819)
July	-0.0175688 (-0.264497)	0.2033305 (0.52697336)
August	0.05010905 (0.77591679)	-0.04201559 (-0.10889216)
September	0.05631579 (0.82061822)	-0.23386456 (-0.57374438)
October	0.05163683 (0.74819853)	0.2017098 (0.49287508)
November	-0.0241971 (-0.3384432)	0.85452771 (2.05407262) ***
December	0.07396224 (1.04079473)	0.3244825 (0.79286846)

Notes: T-Statistic is in parentheses *** significant at 1 percent

5. Conclusion

As can be supported by the output of the study, Bitcoin exhibits market anomalies at a time when the stock market, as represented by the S&P 500 stock index, primarily does not. While the result is not entirely unexpected, there is still a need to understand these results further to identify the root cause of this disconnect. There are many potential explanations for this disconnect, such as the difference in the method and system Bitcoin and the S&P 500 index are traded, where Bitcoin trades in a continuous market while the S&P 500 trades during open market hours and only on weekdays. Another difference is that the S&P 500 is backed by stocks that are regulated and have real assets that back the companies in the index as well as earning records that can be studied by investors, while Bitcoin is a purely speculative asset and there is lack comprehensive government regulation at this time. One last difference is that Bitcoin has not been studied by the investing world to the same extent as U.S. equities and has no existing intrinsic valuation model that can support the development of the expected market value based on other factors outside of market supply and demand.

The final output of the study has provided evidence that Bitcoin does display statistically significant market anomalies during the tested period, which is not consistent with the U.S. equity market during that same period. While there is evidence of market anomalies present, we have provided multiple potential explanations for these deviations from the efficiency that is worthy of further assessments and additional research in the future. As cryptocurrencies overall and Bitcoin specifically are newer instruments to financial markets, we would expect that over time these instruments will stabilize and perhaps become more efficient with this increased level of maturity.

References

Aharon, D. Y., & Qadan, M. (2018). Bitcoin and the day-of-the-week effect. Finance Research Letters.

Arsad, Z. and Coutts, J. A. (1996). The Weekend Effect, Good News, Bad News and The Financial Times Industrial Ordinary Shares Index: 1935-1994. Applied Economics Letters, 3, 797-801.

Bessembinder, H. (1992). Systematic Risk, Hedging Pressure, and Risk Premiums in FuturesMarkets. Review of Financial Studies 5, 637-667.

Bossaerts, P. and Hillion, P. (1991). Market Microstructure Effects of Government Intervention in the Foreign Exchange Market. Review of Financial Studies, Vol 4, 513-541.

Brusa, J., Liu, P., and Schulman, C. (2000). The Weekend Effect, 'Reverse' Weekend Effect, and Firm Size. Journal of Business Finance & Accounting, June/July, 555-574.

Bush, J., Peter and Stephens, J. E. (2016). The Monday effect in the EUR/USD currency pair: Periods of EUR strength and weakness. Journal of Behavioral and Experimental Finance, 10, 72-74.

Caporale, G. M., & Plastun, A. (2018). The day of the week effect in the cryptocurrency market. Finance Research Letters.

Connolly, R.A. (1989). An Examination of the Robustness of the Weekend Effect. Journal of Financial and Quantitative Analysis, 24(2), 133-169.

Cross, F. (1973). The Behavior of Stock Prices on Fridays and Mondays. Financial Analysis Journal, Nov/Dec, 67-69.

Fama, E. (1970). "Effcient Capital Markets: A Review of Theory and Empirical Work. Journal of Finance. 25:2, pp. 383– 417.

Fraz, A., Hassan, A., & Chughtai, S. (2019). Seasonality in Bitcoin Market. NICE Research Journal, 1-11.

French, K. (1980). Stock Returns and the Weekend Effect. Journal of Financial Economics, Vol. 8, 55-69.

Gibbons, M. and Hess, P. (1981). Day of the Week Effects and Asset Returns. Journal of Business, 54(4), 579-596.

Goodhart, C. and L. Figlioli. (1991). Every Minute Counts in the Foreign Exchange Markets. Journal of International Money and Finance, Vol 10, 23–52.

Hattori, T., & Ishida, R. (2019). Do investors arbitrage in the cryptocurrency market? Evidence from the Bitcoin futures market. Evidence from the Bitcoin Futures Market (8 February 2019).

Kamara, A. (1997). New Evidence on the Monday Seasonal in Stock Returns. Journal of Business, 70(1), 63-84.

Kurihara, Y., & Fukushima, A. (2017). The market efficiency of Bitcoin: A weekly anomaly perspective. Journal of Applied Finance and Banking, 7(3), 57.

Levi, M. D. (1978). The Weekend Game: Clearing House vs Federal Funds. Journal of Financial Economics, Vol. 39(2-3), 321-351.

Lyons, R. K. (1995). Tests of Microstructural Hypotheses in the Foreign Exchange Market. Journal of Financial Economics, Vol. 39(2-3), 321-351.

Ma, D., & Tanizaki, H. (2019). The day-of-the-week effect on Bitcoin return and volatility. Research in International Business and Finance, 49, 127-136.

McFarland, J., Pettit, R., and Sung, S. (1982). The Disturbance of Foreign Exchange Prices Changes: Trading Day Effects and Risks Measurement. Journal of Finance, June, 693-715.

Nadarajah, S., & Chu, J. (2017). On the inefficiency of Bitcoin. Economics Letters, 150, 6-9

Nakamoto, S. (2008). Bitcoin: A Peer to Peer Electronic Cash System. https://git.dhimmel.com/bitcoin-whitepaper/

Patell, J. M. and Wolfson, M. A. (1982). Good News, Bad News, and the Intraday Timing of Corporate Disclosures. The Accounting Review, 57(3), 509-527.

Penman, S. (1984). Abnormal Returns to Investment Strategies Based on the Timing of Earnings Reports. Journal of Accounting and Economics, 165-84.

Thatcher, J., and Blenman, L. (2001). Synthetic Trades and Calendar Day Patterns: The Case of the Dollar/Sterling Markets. Financial Review, May, 177-200.

Urquhart, A. (2016). The inefficiency of Bitcoin. Economics Letters, 148, 80-82.

Yu, Hai-Chin, Chiou, Ingyu and Jordan-Wagner, James M. (2008). Does the Weekday Effect of the Yen/Dollar Spot Rates Exist in Tokyo, London, and New York: An Analysis of Panel Probability Distributions, Applied Economics, Vol. 40, 353-375?