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Calendar Anomalies in the Cryptocurrency Market

Abstract

This paper examines weekly and monthly calendar anomalies in the cryptocurrency market, using the returns of seven coins and approximately five years of data. Only two significant results are found for the weekly tests and no significant results are found for the monthly tests. The returns of BTC are significantly higher on Monday compared to the other days of the week and the returns of XMR are significantly higher on Saturday compared to the other days of the week. The empirical results show no signs of inefficiency of the cryptocurrency market as a whole, based on relevant calendar anomalies.

Bachelor Thesis [FEB13100]

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1. Introduction

Calendar anomalies gained a lot of attention during the 1980s, as many literature concerning this subject was published during this period, especially for the stock market. These anomalies could be seen as evidence against the Efficient Market Hypothesis (Fama, 1965; Samuelson, 1965; Jensen, 1978). The cryptocurrency market is a young market, so not much literature concerning calendar anomalies, has been published yet. The cryptocurrency market is really volatile and could be inefficient. The combination of a young market, high volatility and inefficiency, could provide opportunities for abnormal returns by using trading strategies exploiting the calendar anomalies. Therefore I want to research for existence of calendar anomalies in the cryptocurrency market. This results in the following main research question:

Do calendar anomalies exist in the cryptocurrency market?

This question will be answered by testing for weekly and monthly calendar anomalies. Yearly calendar anomalies like the January effect, Chinese New Year effect, etc., cannot yet be tested in the cryptocurrency market, as there are not enough observations to draw a reliable conclusion about these yearly effects.

This research uses the returns of seven coins and approximately five years of data. Dummy regressions are used to test for the weekly and monthly calendar anomalies. Only two significant results are found for the weekly tests and no significant results are found for the monthly tests. The returns of BTC are significantly higher on Monday compared to the other days of the week and the returns of XMR are significantly higher on Saturday compared to the other days of the week. The empirical results show no signs of inefficiency of the cryptocurrency market as a whole, based on relevant calendar anomalies.

My research also indicates whether the calendar anomalies are stronger among coins with higher or lower market capitalizations. Securities with lower market capitalization are often more volatile, which increases risk. Therefore researching for the difference in calendar anomalies, between coins with higher and lower market capitalization, can be interesting for cryptocurrency investors whose portfolio is dominated by coins with lower market capitalizations and want to have a more risky portfolio. This is effected by testing the difference in calendar anomalies between the average of all seven coins and the weighted average of all seven coins. The results indicate no significant differences.

A distinction is made in the cryptocurrency market between Bitcoin and the altcoins. Bitcoin is the first coin that was created; the most popular coin of the market and the coin with the highest market capitalization which dominates approximately 40% of the whole market capitalization. The altcoins are all the other coins besides Bitcoin. My research indicates whether the size of the calendar anomalies are different between Bitcoin and altcoins. This is effected by testing the difference in calendar anomalies between Bitcoin and the weighted average of the six altcoins, but no significant differences are found.

This paper also gives an indication of hedging possibilities for the coins by testing the correlation between the seven coins and by testing the correlation between the coins and stocks. The results provide no strong hedging strategy for the coins. All coins are positively correlated with each other. Only Bitcoin and Litecoin are negatively correlated with stocks, but this correlation is weak.

After the introduction, relevant literature is discussed. Thereafter this paper exemplifies the data and methodology used for the research. Then I provide the empirical results. Finally concluding remarks concerning the research questions of this paper are discussed.

2. Relevant Literature

2.1 Cryptocurrency Market

Only a handful of relevant literature for calendar anomalies in the cryptocurrency market has been published, as the market is a young market. The first most relevant literature published about an anomaly in the cryptocurrency market, concerns the paper from Fukushima and Kurihara (2017). They tested for market efficiency of Bitcoin and whether this efficiency changed over the last few years. The results show evidence that Bitcoin is not efficient but is becoming less inefficient in the most recent years. This could result in Bitcoin returns becoming random in the future.

Two writers from Berlin published three papers concerning the cryptocurrency market, testing the day of the week effect (Caporale and Plastun, 2017), price overreaction (Corporale et al., 2017) and persistence (Caporale and Plastun, 2018). The most relevant paper for my subject is the paper of Caporale and Plastun (2017). These researchers tested for a day of the week effect in the cryptocurrency market. They ran the tests on four cryptocurrencies; Bitcoin, Litecoin, Ripple and Dash. They only found evidence of abnormal positive returns on Mondays for Bitcoin. No evidence was found that the cryptocurrency market as a whole is inefficient. Noticeable is the fact that in this paper the researchers only tested for the five weekdays and

not for the weekends. This is strange because the cryptocurrency market is also open during weekends, as opposed to the stock market which is closed during weekends. In my research I will also test for the day of the week effect, although it will be complementary to the research done by Caporale and Plastun in 2017. My research will contain tests for all seven days of the week and I will test for seven coins instead of four.

2.2 Stock Market

2.2.1 Weekly Calendar Anomalies

Although only a handful of relevant literature for seasonality in the cryptocurrency market has been published, a lot of literature has been published concerning the seasonality in the stock market. Stocks and cryptocurrencies are not the same but they do show some similarities. The well-known day of the week effect was already established by Dubois and Louvet (1996) for the stock market. They found that the returns were lower at the beginning of the week, but not necessarily on Monday. Berument and Kiymaz (2001) tested for the day of the week effect in the stock market for both returns and volatility. They found the highest and lowest returns on Wednesday and Monday, and found the highest and the lowest volatility on Friday and Wednesday, respectively. In my research I will test if the well-known day of the week effect also applies to the cryptocurrency market. The relevant difference between the stock and cryptocurrency market, concerning this calendar anomaly, is the fact that the cryptocurrency market is open during the weekends, as opposed to the stock market, which is closed during the weekends.

Cross (1973) and French (1980) found evidence for the existence of the weekend effect in the stock market. The returns on Mondays were systematically lower than the returns on other weekdays. French (1980) tested if the systematically lower returns occurred only on Mondays, so after a weekend when the stock market is closed, or whether these systematically lower returns also occurred after other days when the market had been closed. He found evidence and concluded that the systematically lower returns on Mondays are not caused by a closed-market effect, but by a weekend effect. A study from Marquering et al. (2006) showed evidence that almost all calendar anomalies were arbitraged away after literature, with evidence of the existence of the calendar anomaly, was published. The weekend effect is one of those calendar anomalies that was arbitraged away. Jaffe et al. (1989) established a twist on the Monday effect and found that the returns for Mondays is positively correlated with the returns from the previous Friday. I will use a different approach in my methodology to test for a weekend effect,

because the cryptocurrency market is open during the weekends, as opposed to the stock market, which is closed during the weekends.

2.2.2 Monthly Calendar Anomalies

The last calendar anomaly relevant to discuss is the turn of the month effect, which was first established by Ariel (1987) for the stock market. He concluded that the mean returns for stocks are positive only for days immediately before and during the first half of calendar months. The study of Lakonishok and Smidt (1988) gave additional insights in this calendar anomaly. Lakonishok and Smidt used ninety years of daily data on the Dow Jones Industrial Average and found evidence for existence of seasonal anomalies in the stock market. As mentioned earlier, the study from Marquering et al. (2006) showed evidence that almost all calendar anomalies were arbitraged away after literature - with evidence of the existence of the calendar anomaly - was published. But the turn of the month effect was the only calendar anomaly that still exist, of the calendar anomalies these researchers tested for. The study from Kunkel (2003) also confirmed the fact that the turn of the month still lives in the stock market. My research will test the same turn of the month effect for the cryptocurrency market.

Hedging

Recently a few papers concerning hedging cryptocurrencies have been published. First Bouri et al. (2017) used a correlation model to examine whether Bitcoin can act as a hedge and safe haven for major world stock indices, bonds, oil, gold, the general commodity index and the US dollar index. Overall, the empirical results indicate that Bitcoin is a poor hedge and is suitable for diversification purposes only. Feng et al. (2018) also found that cryptocurrencies can be a great diversifier but not a hedging tool. Wong et al. (2018) investigated whether cryptocurrencies can be legitimate investments with potential use as a hedging tool. These researchers show that Bitcoin and Litecoin can be useful as a hedge due to negative or zero correlations with other asset classes. Due to their high intrinsic volatility, cryptocurrencies will always add variance to a univariate portfolio, hence increasing portfolio risk.

3. Data & Methodology

3.1 Data

The data for my research is found on coinmarketcap.com. This is the most popular site of the cryptocurrency market to track the prices of the coins. For each coin you can find the historical data of the coin. This historical data contains among other things the date, the closing price, the volume and the market capitalisation per day. Because of the cryptocurrency market being

young, only data from 2013 onwards is available. The data timespan, which is used for the research, starts from the time the coin has available data, up to and including May 7, 2018.

This study examines data for seven cryptocurrencies. Only coins are chosen with a market capitalisation of at least one billion, a data timespan of at least approximately four years of data and coins which have had an impact on the market in the last few years. The coin Verge for example has a market capitalisation of more than one billion and has a data timespan of approximately four years of data, but was not relevant in the cryptocurrency market until May 2017. The data timespan of at least approximately four years of data is necessary to have enough data points to make my research reliable. Only coins with a market capitalisation of at least one billion are used, because coins with lower market capitalisation are too volatile which results in outliers. My research will not be valid if it has many big outliers. The underlying fundamentals of the coin do not apply to this research, as my research only establishes seasonality in the prices of the coins. Bitcoin (BTC), Ripple (XRP), Litecoin (LTC), Stellar (XLM). Dash (DASH), Monero (XMR) and Bytecoin (BCN) are the seven coins that are used for the tests. Table I gives an overview of the seven coins that are used for this research and it shows you the tickers of the coins. The table also shows the market capitalisation on May 7, 2018 to give an indication of their current size in the market. Noticeable is the high market capitalisation of Bitcoin, which is more than one hundred times bigger than the market capitalisation of Bytecoin for example. Lastly, the table will give you the start date of available data for the coins.

Table I: The Seven Coins in this Research

Name	Ticker	Market Cap May 7, 2018	Data Start Date
Bitcoin	BTC	$164.161.000.000	April 29, 2013
Ripple	XRP	$34.132.600.000	August 5, 2013
Litecoin	LTC	$9.689.920.000	April 29, 2013
Stellar	XLM	$7.682.610.000	August 6, 2014
Dash	DASH	$3.913.320.000	Februari 15, 2014
Monero	XMR	$3.773.020.000	May 23, 2014
Bytecoin	BCN	$1.321.620.000	June 18, 2014

The dataset provides data for every day, as the cryptocurrency market is open all seven days. The prices on coinmarketcap.com are stated in Dollars, as this is the most commonly used fiat currency. These prices are calculated by taking the volume weighted average of all prices reported at each market. The closing price is used to calculate the returns per day per coin. The

Coordinated Universal Time is used for the closing time of the day. The returns of a certain coin is calculated as follows:

$$R_i = ((Close_i/Close_{i-1})-1) \times 100\%$$

After calculating the returns of the seven separate coins, three other types of returns are calculated: weighted average returns of the six altcoins, average returns of all seven coins and the weighted average returns of all seven coins. The weighted returns are calculated by adjusting for market capitalisation. Table II shows the descriptive statistics of the returns. Noticeable is the relatively low standard deviation of BTC compared to the altcoins. This is probably caused by the fact that BTC is the oldest coin with the highest market capitalisation. The maturity of the coin results in the stability of the coin.

Table II: Descriptive Statistics of the Returns

Panel A: The Seven Coins							
	BTC	XRP	LTC	XLM	DASH	XMR	BCN
	Returns						
Obs	1835	1737	1835	1371	1543	1446	1420
Mean	0.00333	0.00629	0.00451	0.00756	0.00865	0.00656	0.01105
Std. Dev.	0.0452	0.0919	0.0766	0.0953	0.1066	0.0814	0.1580

Panel B: The Different Types of Returns				
	BTC	Weighted Average Altcoins	Average	Weighted Average
	Returns			
Obs	1835	1835	1835	1835
Mean	0.00333	0.00455	0.00685	0.00341
Std. Dev.	0.0452	0.0652	0.0729	0.0448

To test the correlation between coins and stocks, data of stocks is obtained from the Wharton Research Data Services. Three variables are used for this research: The S&P 500 Index Returns, The NYSE Stock Returns and The Weighted NYSE Stock Returns. The data timespan, which is just used for testing the correlation between the coins and stocks, ends on December 29, 2017. To test for this correlation, only data for weekdays is used for both the coins and the stocks, as the stock market is closed during weekends. The days when the stock market was closed due to a holiday for example, are also removed.

3.2 Methodology

Dummy regressions are used to test for the weekly and monthly calendar anomalies. The seven separate coins, the weighted average of the six altcoins, the average of all seven coins and the weighted average of all seven coins are used as the dependent variable for the different dummy regressions. For all dummy regressions robust standard errors are used in order to ensure valid conclusions, which are drawn from the empirical results. To test whether obtained coefficients are significantly different from zero, t-tests are used. In this research a significance level of 5% is chosen for all significance tests to draw a conclusion.

3.2.1 Weekly Calendar Anomaly tests

A different methodological approach is used in this paper to test for the weekly calendar anomalies in comparison with preceding studies, because the cryptocurrency market is open during the weekends, as opposed to the stock market, which is closed during the weekends. The fact that the stock market is closed for two days, has a big impact on the behavior of stock market investors. All weekly calendar anomalies in the stock market like the day of the week effect, the weekend effect (Monday effect), the twist on the Monday effect, etc. are mainly caused by the closure of these two days. Because a week in the cryptocurrency market looks different, a different approach will be used. My approach towards the weekly calendar anomalies is open minded, as I test for all possible weekly calendar anomalies. Dummy regressions will be used to test for all seven days of the week, to see if any day of the week has significantly different returns from the other days. The following dummy regressions will be used:

$$R = A_0 + A_1 Dmon$$

$$R = A_0 + A_1 Dtue$$

…

This is an example for just the Monday and the Tuesday, but this dummy regression is used all seven days of the week, as Dmon is replaced by Dtue, Dwed, etc. Dmon is 1 for a Monday and 0 for all other days but Monday, Dtue is 1 for a Tuesday and 0 for all other days but Tuesday, etc. This is a dummy regression with a constant and for the dummy regression of the Monday, the constant A_0, represents the average return on all days but Monday, while $A_0 + A_1$ represent the average return for Monday. The difference in return is estimated by A_1. The corresponding

t-value provides empirical evidence whether the return on a Monday is significantly different from the other days of the week.

The weekend might still have an impact on the cryptocurrency market as social lives of investors are different during weekends from weekdays. Therefore a similar dummy regression is used to test if the returns on the weekends are significantly different from the weekdays:

$$R = A_0 + A_1 Dwnd$$

Dwnd is 1 for a Saturday or Sunday and 0 for all weekdays. The constant A_0, represents the average return on weekdays, while $A_0 + A_1$ represent the average return for the weekends.

3.2.2 Monthly Calendar Anomaly tests

After testing for weekly calendar anomalies, this paper tests for monthly calendar anomalies. As a month in the cryptocurrency market looks mostly the same as a month in the stock market, a similar approach is used. Previous research (Lakonishok and Smidt, 1988) showed that the turn of the month could affect the returns. Therefore three different dummy variables are created for the turn of the month. By looking at the returns per day of the month and using previous studies about the turns of the month effect in the stock market, the days for the turn of the month for this research are chosen. Dtom1, Dtom2, Dtom3 were created with turn of the month days [-1, 2], [-1, 3] and [-1, 4], respectively. The following dummy regressions are used for the turn of the month effect:

$$R = A_0 + A_1 Dtom1$$

$$R = A_0 + A_1 Dtom2$$

$$R = A_0 + A_1 Dtom3$$

Dtom = 1 for the days around the turn of the month, Dtom = 0 for all other days of the month. A_0 therefore represents the average return on all days but the turn of the month days, while $A_0 + A_1$ represents the average return for the turn of the month days. The difference in return is estimated by A_1 and the corresponding t-value provides empirical evidence if there is a turn of the month effect or not.

4. Results

4.1 Weekly Calendar Anomaly tests

First weekly calendar anomalies are studied. Table III Shows the weekly dummy regressions results for the seven coins. Only two significant coefficients are found for the weekly dummy

regressions for the seven cryptocurrencies. First, the coefficient of Dmon for BTC has a t-value of 2.01, which is significant at a significance level of 5%. The coefficient of Dmon is 0.00653 and the coefficient of the constant is 0.00239, which indicates the average return for BTC on all days but Monday. The average return on Monday for BTC is 0.00892, which is 0.00239 and 0.00653 combined. 0.00892 is significantly different from 0.00239. This indicates that the average return for BTC on Monday is significantly higher than the average return of the other days of the week. This is not in line with previous study done in the stock market (Cross, 1973; Dubois and Louvet, 1996; French, 1980). In the stock market an opposite effect was established, as the returns were lower in the beginning of the week compared to the other days of the week. But the study from Marquering et al. (2006) showed that this calendar anomaly no longer exist in the stock market, as it had been arbitraged away. The study done by Caporale and Plastun (2017) in the cryptocurrency market, is in line with my results. These researchers tested for a day of the week effect in the cryptocurrency market. They only found evidence of abnormal positive returns on Mondays for Bitcoin, which is in line with my results.

The other significant coefficient is the coefficient of Dsat for XMR. This coefficient has a t-value of 2.22, which is significant at a significance level of 5%. The coefficient of Dsat is 0.01310 and the coefficient of the constant is 0.00469, which indicates the average return for XMR on all days but Saturday. The average return on Saturday for XMR is 0.01779, which is 0.00469 and 0.01310 combined. 0.01779 is significantly different from 0.00469. This indicates that the average return for XMR on Saturday is significantly higher than the average return of the other days of the week.

Table III: Weekly Dummy Regressions Results for The Seven Coins

	BTC	XRP	LTC	XLM	DASH	XMR	BCN
	Returns						
Dom							
Coef.	0.00653	-0.00619	0.00261	0.00723	-0.00224	-0.00002	-0.01228
T-value	2.01*	-1.13	0.42	0.94	-0.18	-0.00	-1.65
Cons. (Coef.)	0.00239	0.00718	0.00414	0.00653	0.00898	0.00656	0.01280
Dtue							
Coef.	0.00088	0.00199	0.00495	-0.00465	-0.00499	0.00028	0.00605
T-value	0.30	0.32	0.93	-0.62	-0.65	0.04	0.28
Cons. (Coef.)	0.00320	0.00601	0.00380	0.00823	0.00937	0.00652	0.01018
Dwed							
Coef.	-0.00478	-0.00151	-0.00304	-0.00075	0.00267	-0.00752	0.00244
T-value	-1.51	-0.30	-0.51	-0.12	0.42	-1.30	0.22

Cons. (Coef.)	0.00401	0.00651	0.00494	0.00767	0.00827	0.00763	0.01070
Dthu							
Coef.	0.00085	0.01003	0.00059	0.00424	0.00673	-0.00409	0.00665
T-value	0.24	1.37	0.11	0.57	1.04	-0.72	0.71
Cons. (Coef.)	0.00321	0.00486	0.00442	0.00696	0.00769	0.00714	0.01009
Dfri							
Coef.	-0.00185	0.00491	-0.00456	-0.00189	0.00380	-0.00311	0.00341
T-value	-0.63	0.89	-0.97	-0.27	0.63	-0.52	0.33
Cons. (Coef.)	0.00359	0.00559	0.00516	0.00783	0.00811	0.00701	0.01056
Dsat							
Coef.	0.0006819	-0.00905	0.00089	-0.00022	-0.00313	0.01310	-0.00641
T-value	0.26	-1.71	0.22	-0.03	-0.48	2.22*	-0.72
Cons. (Coef.)	0.00323	0.00759	0.00438	0.00760	0.00910	0.00469	0.01196
Dsun							
Coef.	-0.00233	-0.00017	-0.00146	-0.00398	-0.00280	0.00132	0.00016
T-value	-0.95	-0.02	-0.41	-0.50	-0.47	0.21	0.02
Cons. (Coef.)	0.00366	0.00632	0.00472	0.00813	0.00906	0.00637	0.01102
Dwnd							
Coef.	-0.00099	-0.00553	-0.00034	-0.00252	-0.00356	0.00865	-0.00375
T-value	-0.48	-1.04	-0.10	-0.43	-0.68	1.82	-0.48
Cons. (Coef.)	0.00361	0.00787	0.00461	0.00828	0.00967	0.00408	0.01212

* $p < 0.05$

Table IV Shows the weekly dummy regressions results for the different types of returns. This table shows no significant coefficients, except for BTC on Monday. This indicates that there is no significant difference in the weekly calendar anomaly between cryptocurrencies with a high and low market capitalization, as there are no significant results for the average and the weighted average returns. The only significant difference between BTC and altcoins, is the fact that BTC is significantly higher on Monday than on other days of the week. Altcoins do not show this effect for the Monday. The cryptocurrency market as a whole does not show signs of inefficiency for weekly calendar anomalies, except for BTC on Monday and XMR on Saturday. This conclusion is in line with the study from Caporale and Plastun (2017), who also found no evidence that the cryptocurrency market as a whole is inefficient, based on their study of the day of the week effect.

Table IV: Weekly Dummy Regressions Results for The Different Types of Returns

	BTC	Weighted Average Altcoins	Average	Weighted Average
	Returns			
Dom				
Coef.	0.00653	-0.00313	0.00140	0.00530
T-value	2.01	-0.66	0.30	1.63
Cons. (Coef.)	0.00239	0.00500	0.00665	0.00265
Dtue				
Coef.	0.00088	0.00222	0.00079	0.00075
T-value	0.30	0.46	0.17	0.25
Cons. (Coef.)	0.00320	0.00424	0.00674	0.00330
Dwed				
Coef.	-0.00478	0.00064	-0.00258	-0.00377
T-value	-1.51	0.14	-0.67	-1.19
Cons. (Coef.)	0.00401	0.00446	0.00722	0.00395
Dthu				
Coef.	0.00085	0.00466	0.00295	0.00121
T-value	0.24	0.99	0.73	0.34
Cons. (Coef.)	0.00321	0.00389	0.00643	0.00324
Dfri				
Coef.	-0.00185	-0.00011	-0.00134	-0.00179
T-value	-0.63	-0.03	-0.40	-0.63
Cons. (Coef.)	0.00359	0.00457	0.00704	0.00366
Dsat				
Coef.	0.0006819	-0.00413	-0.00047	0.00010
T-value	0.26	-1.23	-0.14	0.04
Cons. (Coef.)	0.00323	0.00514	0.00692	0.00399
Dsun				
Coef.	-0.00233	-0.00014	-0.00075	-0.00182
T-value	-0.95	-0.03	-0.23	-0.75
Cons. (Coef.)	0.00366	0.00457	0.00696	0.00367
Dwnd				
Coef.	-0.00099	-0.00256	-0.00073	-0.00103
T-value	-0.48	-0.84	-0.27	-0.50
Cons. (Coef.)	0.00361	0.00529	0.00706	0.00370

* $p < 0.05$

A noticeable difference between the weekend and the weekdays is the fact that the volatility and volume is lower during the weekend, compared to the weekdays. Table IX in the appendix shows the standard deviation per day of the week for the different types of returns, as standard deviation can be seen as a proxy for volatility. Table X in the appendix shows the volume per day of the week for the seven cryptocurrencies. The lower volume during the weekends could be explained by the fact that traders pay less attention to the market during weekends because of their busy social lives during the weekends. No significant difference in returns between the weekend and weekdays was found though. Further research could test for the significance of the difference in volatility and volume between the weekend and weekdays. Research could also indicate the difference in volatility between the coins, and test whether the size of the coins effect the standard deviation. As earlier mentioned, BTC has a relatively low standard deviation compared to the altcoins. This is probably caused by the fact that BTC is the oldest coin with the highest market capitalisation. The maturity of the coin could result in the stability of the coin.

4.2 Monthly Calendar Anomaly Tests

After studying weekly calendar anomalies, monthly calendar anomalies were studied. Table V shows the monthly dummy regressions results for the seven cryptocurrencies. This table shows no significant coefficients. This indicated that the returns of the seven cryptocurrencies around the turn of the month are not significantly different from the other days of the month.

Table V: Monthly Dummy Regressions Results for The Seven Coins

	BTC	XRP	LTC	XLM	DASH	XMR	BCN
	Returns						
Dtom1							
Coef.	0.00146	0.00623	-0.00117	-0.00090	0.00196	0.00110	-0.00538
T-value	0.51	0.64	-0.28	-0.12	0.30	0.21	-0.56
Cons. (Coef.)	0.00313	0.00548	0.00467	0.00768	0.00840	0.00642	0.01176
Dtom2							
Coef.	0.00160	0.00480	0.00038	-0.00176	0.00015	0.00013	-0.00594
T-value	0.61	0.59	0.10	-0.27	0.03	0.03	-0.67
Cons. (Coef.)	0.00306	0.00551	0.00445	0.00785	0.00863	0.00654	0.01203
Dtom3							
Coef.	0.00117	0.00292	0.00019	0.00031	-0.00181	0.00095	-0.00230
T-value	0.47	0.42	0.05	0.05	-0.33	0.20	-0.26
Cons. (Coef.)	0.00310	0.00572	0.00447	0.00750	0.00901	0.00637	0.01150

* $p < 0.05$

Table VI shows the monthly dummy regressions results for the different types of returns. Also this table shows no significant coefficients as well. This indicates that there is no significant difference in the monthly calendar anomaly between cryptocurrencies with a high and low market capitalization, as there are no significant results for the average and the weighted average returns. Also is there no significant difference between BTC and altcoins. The market as a whole does not show signs of inefficiency for monthly calendar anomalies. One could expect significantly higher returns around the turn of the month compared to the other days of the month, as investors and traders have higher cash flows around the turn of the month, because of salary payments, dividend payments, etc. The results are not in line with literature about the stock market concerning the turn of the month effect (Ariel, 1987; Kunkel et al., 2003; Lakonishok and Smidt, 1988; Marquering, 2006). These researchers showed evidence for significant higher returns around the turn of the month in the stock market. Also no noticeable difference in volatility and volume between the turn of the month days and the other days of the month is established.

Table VI: Monthly Dummy Regressions Results for The Different Types of Returns

		Weighted Average		Weighted Average
	BTC	Altcoins	Average	
		Returns		
Dtom1				
Coef.	0.00146	-0.00077	-0.00163	0.00140
T-value	0.51	-0.16	-0.46	0.48
Cons. (Coef.)	0.00313	0.00466	0.00707	0.00322
Dtom2				
Coef.	0.00160	0.00064	-0.00070	0.00164
T-value	0.61	0.15	-0.21	0.62
Cons. (Coef.)	0.00306	0.00445	0.00697	0.00314
Dtom3				
Coef.	0.00117	-0.00053	-0.00119	0.00102
T-value	0.47	-0.13	-0.38	0.41
Cons. (Coef.)	0.00310	0.00466	0.00709	0.00321

* $p < 0.05$

4.3 Hedging

Table VII shows the correlation between the seven coins in this paper and gives an indication of hedging possibilities within the cryptocurrency market. BTC and LTC have the highest positive correlation. Graph A and C in the appendix show the average returns per day of the week for BTC and LTC, and these graphs look very similar with high returns in the beginning of the week. The high positive correlation between the two coins might not be a coincidence because Litecoin is a 'fork' of Bitcoin, which means their technology is correlated. So coins with correlated underlying technology are not a good hedging strategy. The cryptocurrency market has a lot of coins that represent different types of projects like a currency to exchange value, an exchange to trade coins, a platform to build apps, etc. To spread your risk, it might be a good hedging strategy to invest in different types of projects. This strategy is only relevant for investors who study the underlying technology of the projects.

Pure traders are more interested in just the correlation between the different coins for a possible hedging strategy. Noticeable about Table VII is the fact that all coins are positively correlated, which makes hedging a portfolio with these seven coins difficult. Reducing risk in a portfolio with these seven coins can only be done by simply having multiple coins in the portfolio and buying coins with the lowest positive correlation.

Table VII: Correlation Between The Seven Coins

Corr.	BTC	XRP	LTC	XLM	DASH	XMR	BCN
BTC	1						
XRP	0.2064	1					
LTC	0.5304	0.2408	1				
XLM	0.2628	0.4729	0.2580	1			
DASH	0.3798	0.1060	0.3259	0.1771	1		
XMR	0.4268	0.1600	0.3192	0.2377	0.3363	1	
BCN	0.2383	0.1029	0.1714	0.1777	0.1047	0.1254	1

Table VIII shows the correlation between stocks and coins, which gives an indication of possible hedging possibilities between stocks and coins. Coins can be seen as a security of blockchain projects and stocks are securities of companies that are not built on blockchain. Blockchain is a new upcoming technology, with decentralisation as the point of focus. These blockchain projects can be seen as a competitor to a lot of existing projects that are built on the ordinarily used centralised technology. Table VIII shows no signs of strong correlations between the stocks and coins. But noticeable are the negative correlations between BTC and

LTC, and the stock market. This is probably no coincidence, as Bitcoin is the face of the cryptocurrency market and is seen as a competitor to the stock market, as explained above. LTC probably follows BTC in this correlation, based on the previous explained correlation between LTC and BTC. For example, a cryptocurrency investor could hedge his BTC holdings by investing in the S&P 500 Index to reduce risk. This strategy is in line with the results from Wong et al. (2018), as their results show that BTC and LTC can be useful as a hedge due to negative or zero correlations with other asset classes. But again, all correlations between the stocks and coins are weak. Further research could test for the significance of the correlations and test for hedging opportunities with other securities.

Table VIII: Correlation Between Stocks and Coins

Panel A: The Seven Coins							
	BTC	XRP	LTC	XLM	DASH	XMR	BCN
	Returns						
S&P 500 Index Returns	-0.0253	0.0183	-0.0184	0.0282	0.0191	0.0295	0.0112
NYSE Stock Returns	-0.0185	0.0279	-0.0204	0.0050	0.0190	0.0441	0.0166
Weighted NYSE Stock Returns	-0.0281	0.0202	-0.0218	0.0245	0.0228	0.0389	0.0086

Panel B: The Different Types of Returns				
	BTC	Weighted Average Altcoins	Average	Weighted Average
	Returns			
S&P 500 Index Returns	-0.0253	0.0054	0.0046	-0.0240
NYSE Stock Returns	-0.0185	0.0151	0.0098	-0.0151
Weighted NYSE Stock Returns	-0.0281	0.0068	0.0045	-0.0258

5. Conclusion

The empirical results of this paper show no signs of inefficiency for the cryptocurrency market as a whole, based on tests for weekly and monthly calendar anomalies in returns. Only two significant results are found for the weekly tests and no significant results are found for the monthly tests. Only returns of BTC are significantly higher on Monday compared to the other days of the week and returns of XMR are significantly higher on Saturday compared to the

other days of the week. No noticeable significant differences are found between coins with a high and low market capitalization. Also, there are no significant differences found between Bitcoins and altcoins. These conclusions are not in line with previous study done for the stock market, where multiple calendar anomalies were found.

This paper also gives an indication of hedging possibilities for the coins. The results give no strong hedging strategy for the coins. All coins are positively correlated with each other. Only BTC and LTC are negatively correlated with stocks, but this correlation is weak.

This paper only tests for weekly and monthly calendar anomalies. Yearly calendar anomalies like the January effect, Chinese New Year effect, etc., are not tested in this paper, as there are not enough observations to draw a reliable conclusion about these yearly effects. In a couple of years further research could be done for yearly calendar anomalies. Also in the future when the cryptocurrency market has matured a little, research could indicate whether these calendar anomalies changed over the last few years. Furthermore this paper only tests for calendar anomalies in returns, where future research could also test for calendar anomalies in volatility and volume. Day traders use volatility and volume in their strategy, and the high volatility in the cryptocurrency market is attractive for day traders. Therefore research for calendar anomalies in volatility and volume can be interesting for these day traders.

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Appendix

Weekly Calendar Anomalies

Table IX: Statistics per Day of the Week for The Seven Coins

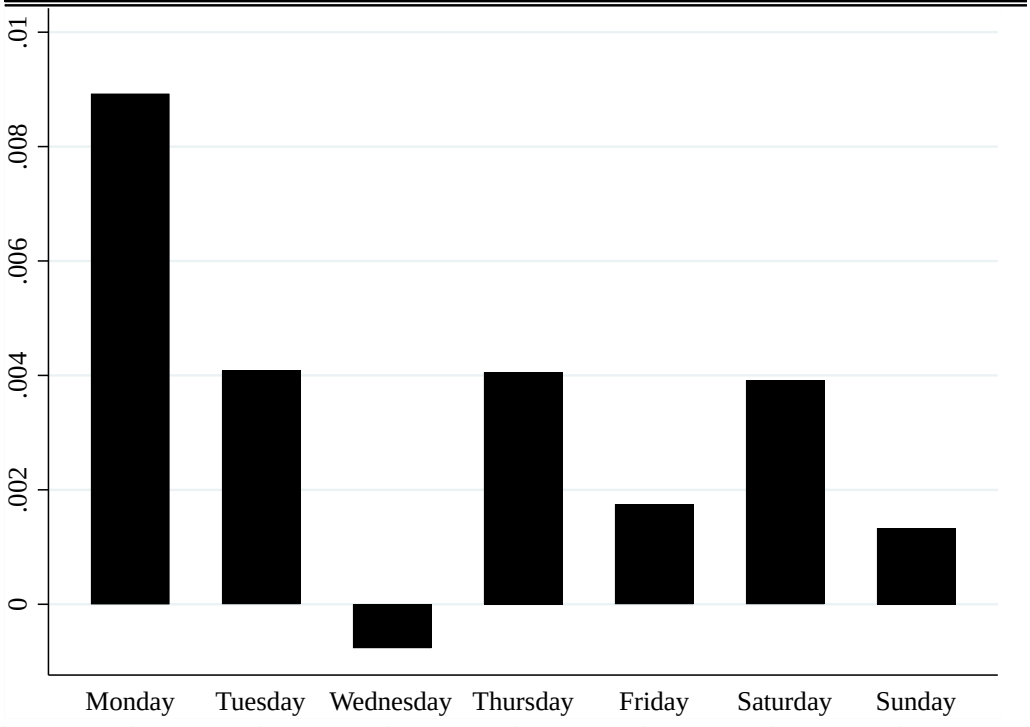
	BTC	XRP	LTC	XLM	DASH	XMR	BCN
	Returns						
Monday							
Mean	0.00892	0.00099	0.00675	0.01376	0.00673	0.00654	0.00052
Std. Dev.	0.0496	0.0775	0.0977	0.1009	0.1868	0.0890	0.0809
Tuesday							
Mean	0.00408	0.00800	0.00876	0.00358	0.00437	0.00680	0.01624
Std. Dev.	0.0436	0.0910	0.0801	0.0978	0.1055	0.0853	0.2986
Wednesday							
Mean	-0.00077	0.00500	0.00191	0.00692	0.01094	0.00011	0.01313
Std. Dev.	0.0481	0.0691	0.0911	0.0829	0.0836	0.0763	0.1473
Thursday							
Mean	0.00406	0.01489	0.00502	0.01120	0.01443	0.00305	0.01675
Std. Dev.	0.0553	0.1100	0.0809	0.0978	0.0854	0.0744	0.1151
Friday							
Mean	0.00175	0.01050	0.00060	0.00594	0.01191	0.00390	0.01397
Std. Dev.	0.0436	0.0776	0.0693	0.0882	0.0776	0.0798	0.1340
Saturday							
Mean	0.00391	-0.00147	0.00527	0.00738	0.00597	0.01778	0.00555
Std. Dev.	0.0378	0.0740	0.0578	0.0950	0.0868	0.0783	0.1078
Sunday							
Mean	0.00133	0.00615	0.00325	0.00415	0.00625	0.00769	0.01118
Std. Dev.	0.0348	0.1284	0.0470	0.1042	0.0769	0.0857	0.1238
Total							
Mean	0.00333	0.00629	0.00451	0.00756	0.00865	0.00656	0.01105
Std. Dev.	0.0452	0.0919	0.0766	0.0953	0.1066	0.0814	0.1580
Obs	1835	1737	1835	1371	1543	1446	1420

Table X: Statistics per Day of the Week for The Different Types of Returns

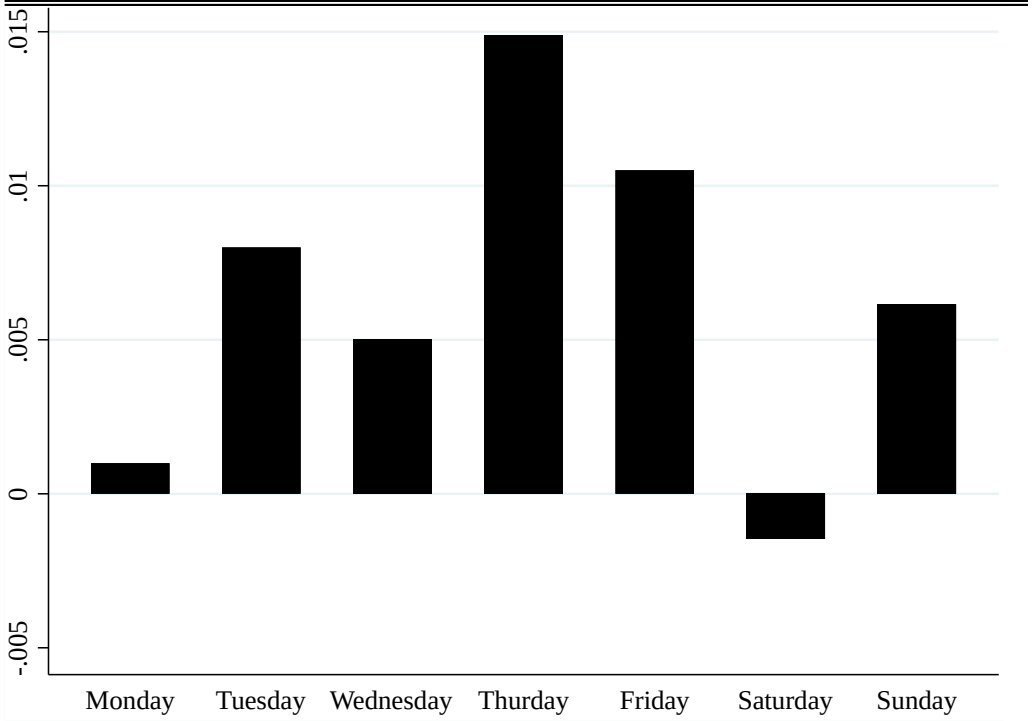
	BTC	Weighted Average Altcoins	Average	Weighted Average
	Returns			
Monday				
Mean	0.00892	0.00187	0.00805	0.00795
Std. Dev.	0.0496	0.0729	0.0730	0.0497
Tuesday				
Mean	0.00408	0.00646	0.00753	0.00405

Std. Dev.	0.0436	0.0738	0.0709	0.0439
Wednesday				
Mean	-0.00077	0.00511	0.00464	0.00018
Std. Dev.	0.0481	0.0680	0.0575	0.0479
Thursday				
Mean	0.00406	0.00855	0.00938	0.00445
Std. Dev.	0.0553	0.0715	0.0613	0.0548
Friday				
Mean	0.00175	0.00446	0.00570	0.00187
Std. Dev.	0.0436	0.0586	0.0485	0.0424
Saturday				
Mean	0.00391	0.00102	0.00645	0.00350
Std. Dev.	0.0378	0.0468	0.0497	0.0367
Sunday				
Mean	0.00133	0.00444	0.00620	0.00185
Std. Dev.	0.0348	0.0609	0.0474	0.0347
Total				
Mean	0.00333	0.00455	0.00685	0.00341
Std. Dev.	0.0452	0.0652	0.0591	0.0448
Obs	1835	1835	1835	1835

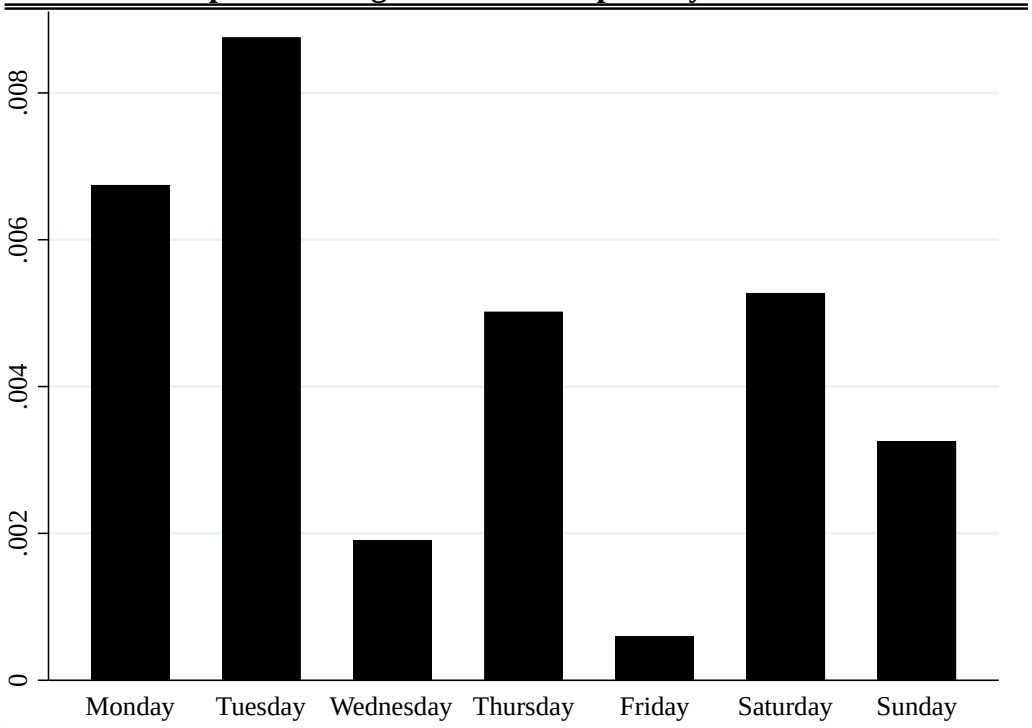
Graph A: Average Returns BTC per Day of the Week



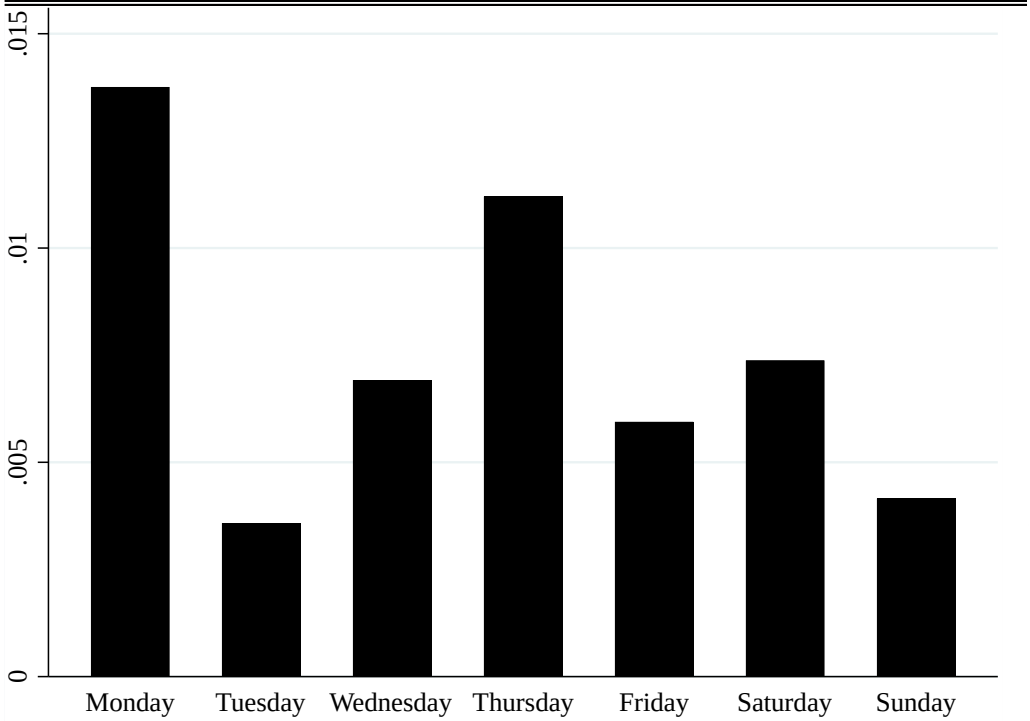
Graph B: Average Returns XRP per Day of the Week



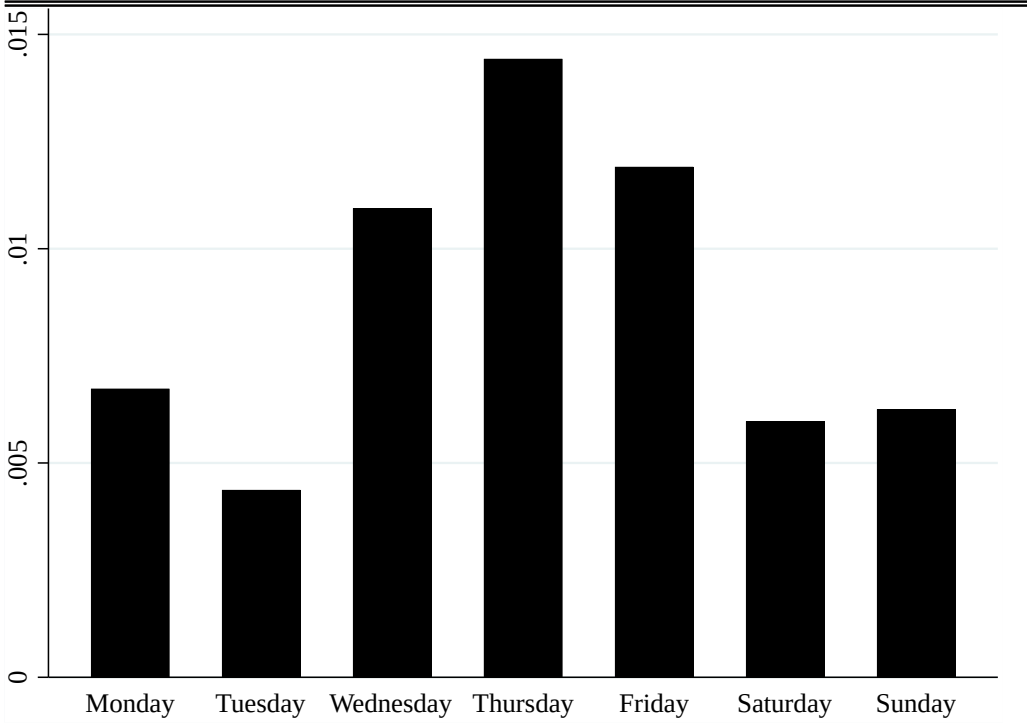
Graph C: Average Returns LTC per Day of the Week



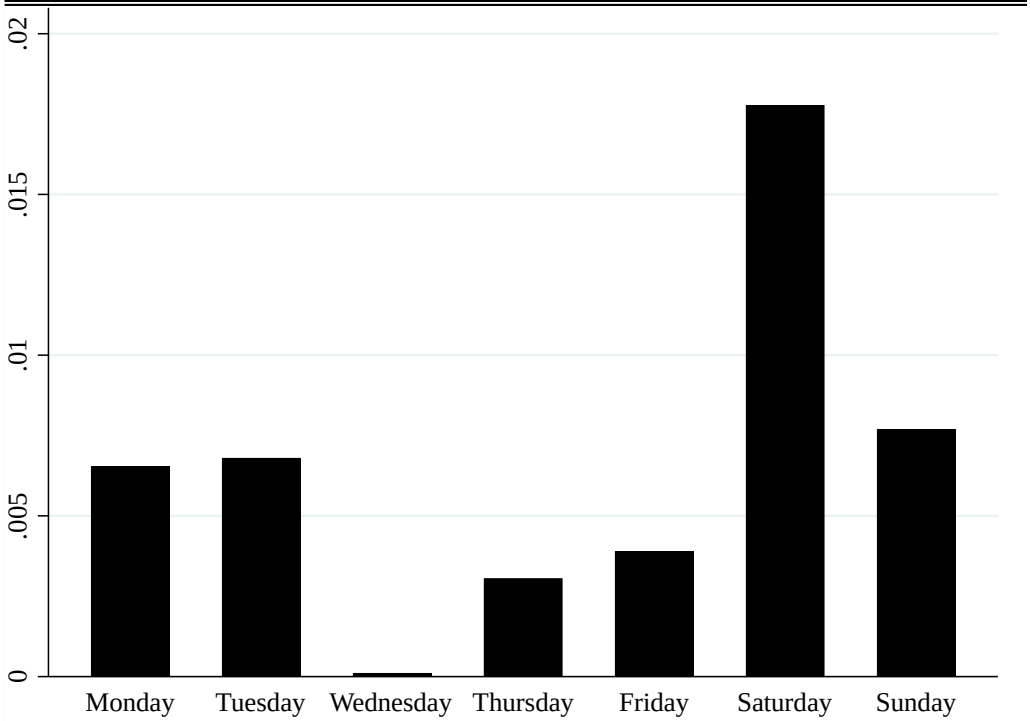
Graph D: Average Returns XLM per Day of the Week



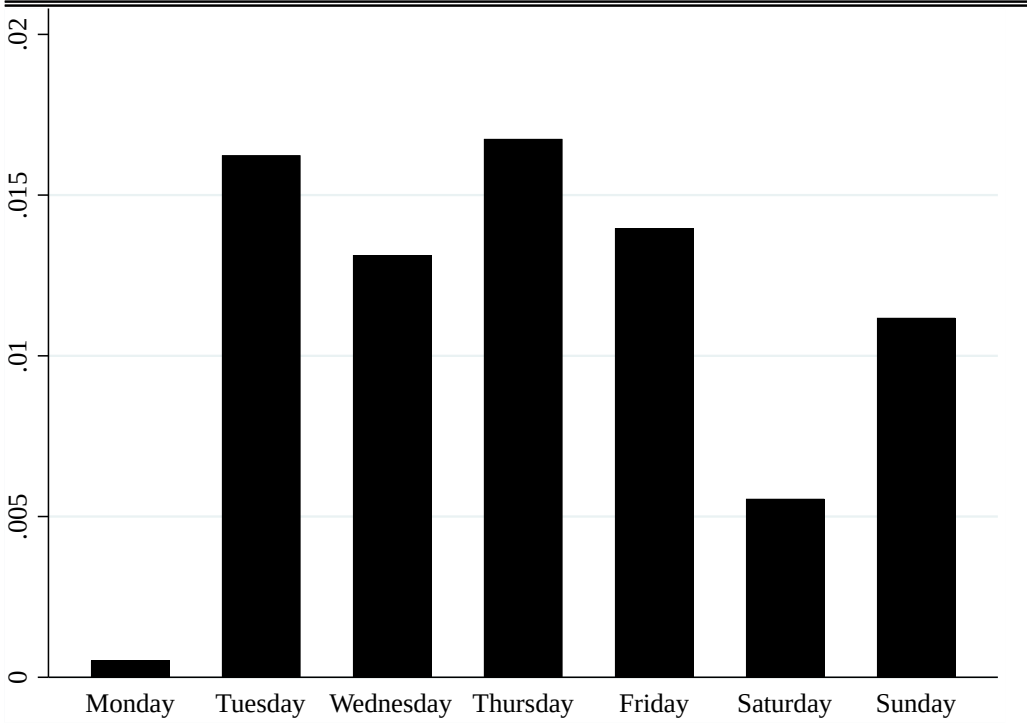
Graph E: Average Returns DASH per Day of the Week



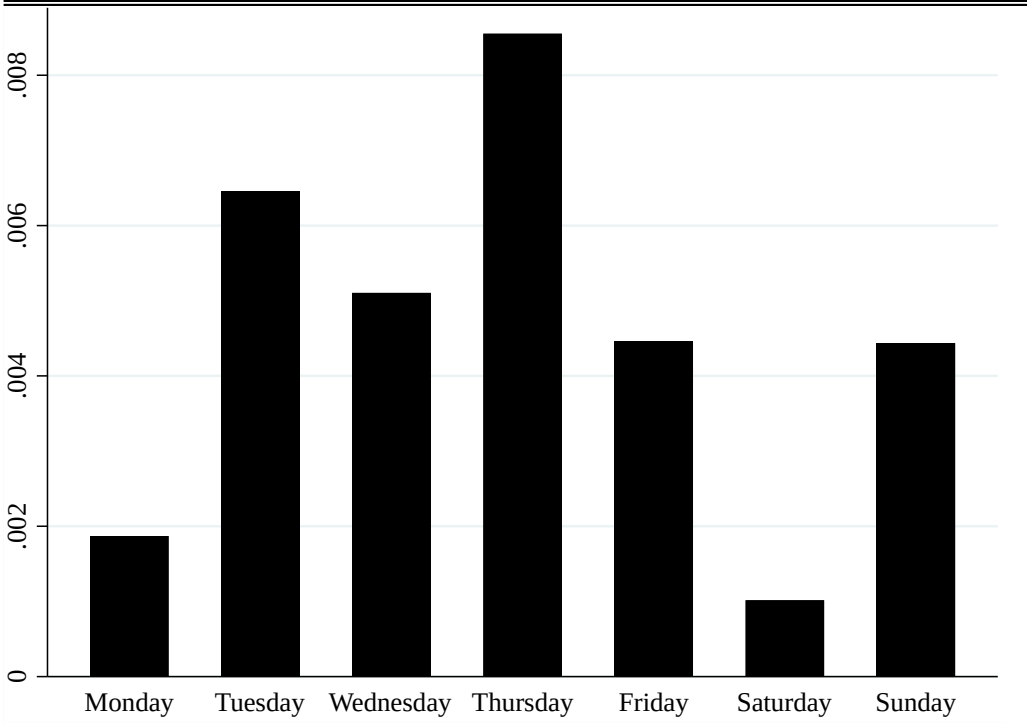
Graph F: Average Returns XMR per Day of the Week



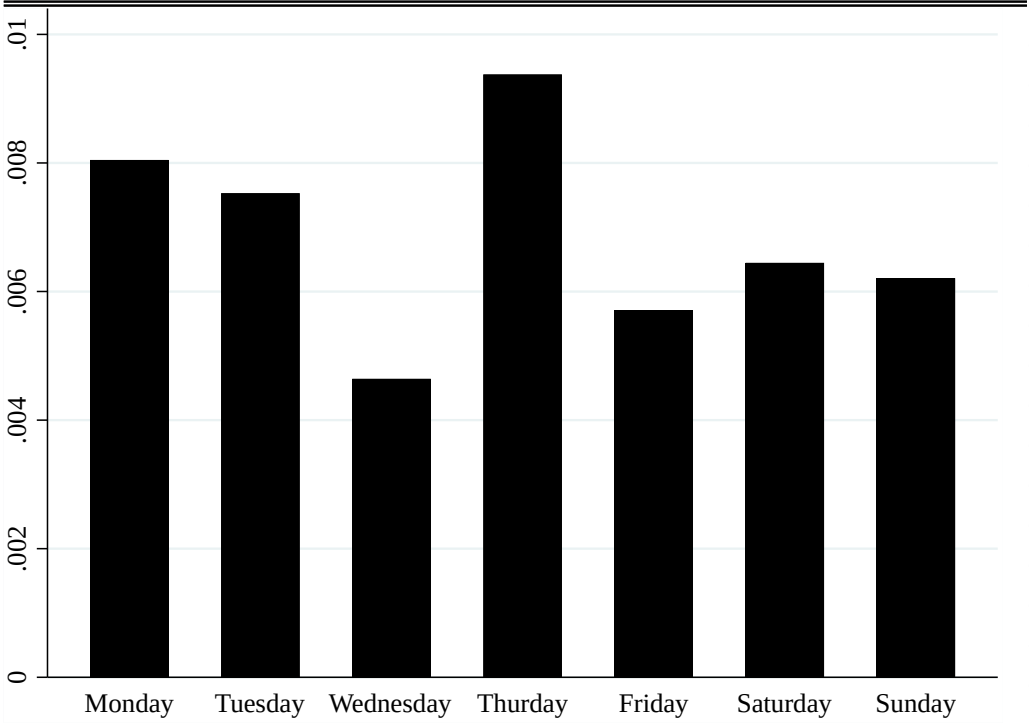
Graph G: Average Returns BCN per Day of the Week



Graph H: Total Weighted Average Altcoins Returns per Day of the Week



Graph I: Total Average Returns per Day of the Week



Graph J: Total Weighted Average Returns per Day of the Week

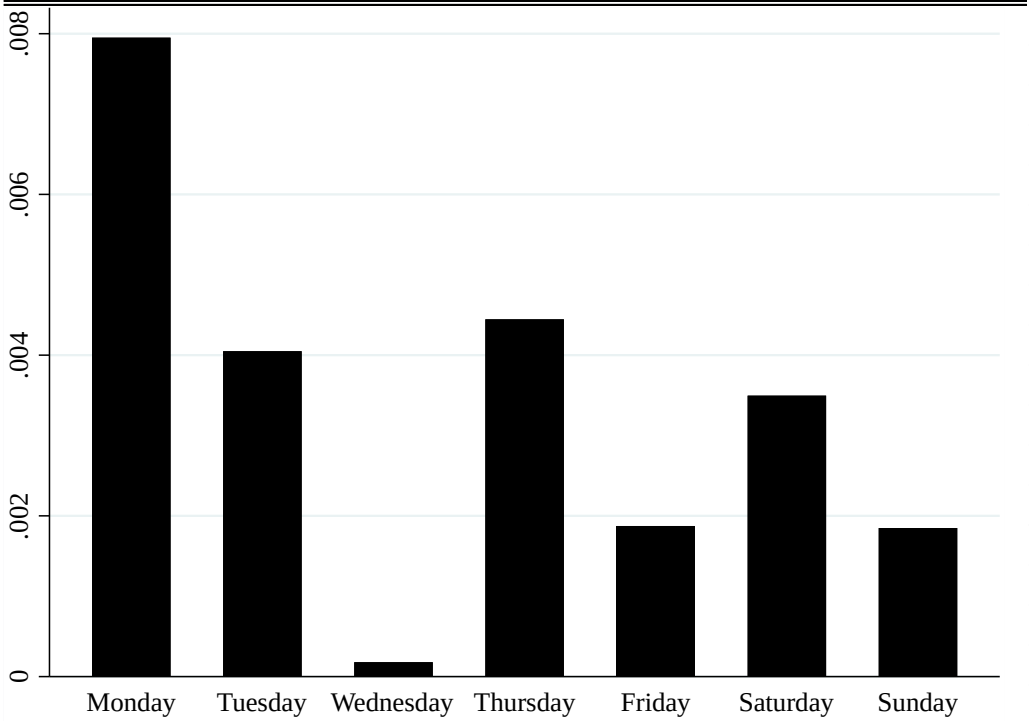


Table XI: Volume per Day of the Week for The Seven Coins

	BTC	XRP	LTC	XLM	DASH	XMR	BCN	Total
	Volume ($billion)							
Monday	1.185	0.133	0.122	0.022	0.023	0.019	0.013	1.500
Tuesday	1.297	0.172	0.149	0.024	0.025	0.024	0.011	1.685
Wedsnesday	1.346	0.200	0.146	0.031	0.028	0.026	0.013	1.770
Thursday	1.379	0.251	0.146	0.026	0.027	0.021	0.013	1.845
Friday	1.374	0.229	0.145	0.027	0.024	0.021	0.014	1.816
Saturday	1.151	0.164	0.125	0.020	0.024	0.019	0.014	1.499
Sunday	1.123	0.136	0.112	0.018	0.025	0.017	0.012	1.427
Total Average	1.265	0.183	0.135	0.024	0.025	0.021	0.013	1.649

Monthly Calendar Anomalies

Table XII: Statistics per Turn of the Month for The Seven Coins

	BTC	XRP	LTC	XLM	DASH	XMR	BCN
				Returns			
Dtom1							
Mean	0.00427	0.00864	0.00466	0.00782	0.00720	0.00732	0.00920
Std. Dev.	0.0423	0.1230	0.0609	0.0949	0.0787	0.0710	0.1272
Other Days (1)							
Mean	0.00310	0.00572	0.00447	0.00750	0.00901	0.00637	0.01150
Std. Dev.	0.0459	0.0826	0.0801	0.0955	0.1125	0.0838	0.1647
Dtom2							
Mean	0.00466	0.01030	0.00483	0.00610	0.00878	0.00667	0.00609
Std. Dev.	0.0409	0.1322	0.0582	0.0896	0.0825	0.0677	0.1144
Other Days (2)							
Mean	0.00306	0.00551	0.00445	0.00785	0.00863	0.00654	0.01203
Std. Dev.	0.0460	0.0817	0.0798	0.0965	0.11082	0.0839	0.1653
Dtom3							
Mean	0.00427	0.00864	0.00466	0.00782	0.00720	0.00732	0.00920
Std. Dev.	0.0423	0.1230	0.0609	0.0949	0.0787	0.0710	0.1272
Other Days (3)							
Mean	0.00310	0.0057	0.00447	0.00750	0.00901	0.00637	0.01550
Std. Dev.	0.0459	0.0826	0.0801	0.0955	0.1125	0.0838	0.1647
Total							
Mean	0.00333	0.00629	0.00451	0.00756	0.00865	0.00656	0.01105
Std. Dev.	0.0452	0.0919	0.0766	0.0953	0.1066	0.0814	0.1580
Obs	1835	1737	1835	1371	1543	1446	1420

Table XIII: Statistics per Turn of the Month for The Different Types of Returns

	BTC	Weighted Average Altcoins	Average	Weighted Average
		Returns		
Dtom1				
Mean	0.00427	0.00389	0.00590	0.00423
Std. Dev.	0.0423	0.0719	0.0510	0.0423
Other Days (1)				
Mean	0.00310	0.00466	0.00709	0.00320
Std. Dev.	0.0459	0.0642	0.0609	0.0454
Dtom2				
Mean	0.00466	0.00509	0.00626	0.00477

Std. Dev.	0.0409	0.0700	0.0505	0.0416
Other Days (2)				
Mean	0.00306	0.00445	0.00697	0.00314
Std. Dev.	0.0460	0.0643	0.0607	0.0454
Dtom3				
Mean	0.00427	0.00413	0.00590	0.00423
Std. Dev.	0.0423	0.0673	0.0510	0.0423
Other Days (3)				
Mean	0.00310	0.00466	0.00709	0.00320
Std. Dev.	0.0459	0.0647	0.0609	0.0454
Total				
Mean	0.00333	0.00455	0.00685	0.00341
Std. Dev.	0.0452	0.0652	0.0591	0.0448
Obs	1835	1835	1835	1835

Table XIV: Volume per Turn of the Month for The Seven Coins

	BTC	XRP	LTC	XLM	DASH	XMR	BCN	Total
	Volume ($billion)							
Dtom1	1.213	0.166	0.122	0.031	0.024	0.019	0.011	1.568
Other Days (1)	1.273	0.186	0.137	0.023	0.025	0.021	0.013	1.661
Dtom2	1.227	0.180	0.133	0.031	0.024	0.018	0.011	1.607
Other Days (2)	1.273	0.184	0.135	0.023	0.025	0.021	0.013	1.657
Dtom3	1.255	0.187	0.135	0.032	0.024	0.019	0.013	1.646
Other Days (3)	1.267	0.183	0.135	0.022	0.025	0.021	0.013	1.649
Total Average	1.265	0.183	0.135	0.024	0.025	0.021	0.013	1.649