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Bitcoin returns and the Monday Effect

La rentabilidad de Bitcoin y el efecto lunes

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Abstract: This paper examines whether the well-known Monday Effect found in stock and Treasury Bills markets also occurs in the Bitcoin market, which differs markedly from other markets due to its continuous trading. The findings of the paper suggest that one explanation for the Monday effect may be found in interrupted periods, as Monday trading occurs after one or more days without any trade. The paper uses a Student's t-test for a statisticially significant difference in the average daily returns of Monday as compared with other days, finding that returns are significantly higher on Mondays. This is corroborated by a regression analysis indicating that there are above average returns on Mondays.
Keywords: Bitcoin, Monday effect, cryptocurrency
JEL Classification: G14

Resumen: Esta investigación verifica si el efecto lunes que se encuentra en los mercados de acciones y letras del Tesoro también se produce en el mercado de Bitcoin, que difiere profundamente de otros mercados porque nunca se cierra. Una posible explicación para el efecto lunes es que la negociación del lunes ocurre después de uno o más días sin ninguna transacción. Se usó la prueba t-Student para verificar si los retornos diarios promedio de cada día de la semana son significativamente diferentes de otros días y encontramos que los retornos del lunes son significativamente más altos que en otros días. Después de eso, estimamos un modelo de regresión para confirmar que el retorno promedio del lunes es positivo y superior al promedio de otros días y se confirmó.
Palabras Claves: Bitcoin, Efecto lunes, criptomoneda
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1. Introduction

A vast financial literature has explored anomalies that would contradict the Efficient Market Hypothesis (EMH) in equity markets. One such anomaly is the calendar effect found by French (1980) that identified a significantly negative average return on Monday and on Tuesday after Monday holiday. His explanation for this effect was the occurrence of the weekend and not by a general closed market effect.

Fields (1931) examined the closing price of Dow Jones Industrial Average (DJIA) on Saturday and compared with the closing price on Friday and Monday to verify if the market closed on Sunday affect the pattern of the DJIA.

He found 717 weeks when the difference between the closing price on Friday and Saturday where significant, and it was higher on Saturday in 410 weeks (57.2%). In the comparison between Saturday and Monday, the difference was significant in 715 weeks and Saturday higher in 374 weeks (52.3%) and concluded that the weekend without negotiation affected stock prices.

Gibbons and Hess (1981) tested the weekend effect in the Treasury Bills markets and found below-average returns for bills on Monday, consistent with the aforementioned pattern observed in the stock market.

Thaler (1987) suggested a behavioral explanation for superior returns before weekends and holidays as opposed to after weekends. His assertion was that the mood of participants affected returns, premised on the notion that investors would have good moods on Fridays and bad moods on Mondays. Thaler (1987) considered this behavior consistent with observations made in other fields, as for example the higher suicide rates observed on Mondays.

At present, there is an emergent new market that is garnering heightened attention from investors and academics: that of cryptocurrencies.

Bitcoin is the best-known and highest-priced asset in this new market, with market capitalization of US$ 125 billion (as of November 5, 2017), which is in turn 4.4 times higher than the market capitalization of Ethereum, the second highest-priced cryptocurrency. The evolution of Bitcoin price can be observed in Figure 1.

Figure 1: The evolution of Bitcoin price
Source: Coindesk

The first known transaction involved Bitcoin occurred on 22nd May, 2010 when 10,000 Bitcoins were used to buy two pizzas costing US$ 25, implying a price of 25 cents per Bitcoin . 7.5 years later, that same amount of Bitcoin is worth US$ 75 million.

According to its pseudonymous creator Nakamoto (2008), Bitcoin is based on a peer-to-peer network with proof-of-work structure.Ermakova et al. (2017) have identified a series of benefits in the usage of Bitcoin, including the exclusion of financial institutes as intermediaries (see also Levin, 2013; Mullan, 2014) and possibility of lower transaction fees (see also Mullan, 2014; Brito, 2013). Other authors have considered it as an alternative to the classical banking system (Carrick, 2016).

Another important characteristic we emphasize in this paper is that the cryptocurrencies markets never close. It is possible buy or sell Bitcoin any time and any day, even during the night or on Sundays and holidays.. This augments the real-time sensitivity of Bitcoin prices to changes in exogenous events, as they may react more readily, even when other trading markets are closed.

This allows us to revisit the Weekend Effect though another prism. If the Weekend Effect is the consequence of closed and non-trading days, the effect should not be observed in Bitcoin returns. On the other hand, if it is a mood effect, the weekend effect should also be observed in the Bitcoin market.

The rest of the paper is organized as follows: a literature review on cryptocurrencies is provided in section 2; the methodology used to identify the Monday effect is described in section 3; results are reported in section 4, and a conclusion is given in section 5.

2. Cryptocurrencies

At its simplest, a cryptocurrency can be thought of as a digital asset that is constructed to function as a medium of exchange, premised on the technology of cryptography, to secure the transactional flow, as well as to control the creation of additional units of the currency.

There is a plethora of cryptocurrencies worldwide, including Bitcoin, Ethereum, Primecoin; and many theoretical ones have been proposed as well, such as Spacecoin Park et al. (2015) or Solidus (Abraham et al., 2016). As early as 2014, Iwamura et al. (2014) counted more than 100 cryptocurrencies and the number has only grown since then. Farell (2015) states that "since the release of the pioneer anarchic cryptocurrency, Bitcoin, to the public in January 2009, more than 550 cryptocurrencies have been developed, the majority with only a modicum of success". Until November 5, 2017 was identified 1,276 cryptocurrencies.

The interest in cryptocurrencies is explained by multiple sources of value that they create, and to this point, Kazan et al. (2015) identify six digital business models for cryptocurrencies that are in turn driven by three modes of value configurations, "with their own distinct logic for value creation and mechanisms for value capturing." They find that value-chain and value-network driven business models "commercialize their products and services for each value unit transfer, whereas commercialization for value-shop driven business models is realized through the subsidization of direct users by revenue generating entities," (Kazan et al., 2015). Cocco et al. (2017) suggest the creation of an "artificial financial market" for studying cryptocurrency markets. Darlington (2014) applies benefit analysis to mapping the adoption of cryptocurrencies, while Brenig et al. (2015) use economic methods to analyze cryptocurrency-backed money laundering.

Cryptocurrencies fluctuate dramatically in value. Bitcoin, prime among traded cryptocurrencies, has grown by an astounding amount in value as of this writing. As Hayes (2017) notes, there are various determinants in the valuation of Bitcoin. Can we stabilize the price of a Cryptocurrency? Iwamura et al. (2014) suggest that a better understanding of the design of Bitcoin and its potential to compete with Central Bank money is necessary.

Ametrano (2016) summarizes the problem as follows: "so far the affirmation of cryptocurrency as better money has been thwarted by dramatic deflationary price instability. Successful at disposing of any central monetary authority, bitcoin has elected to have a fixed deterministic inelastic monetary policy, establishing itself more as digital gold than as a

currency. Price stability could be achieved by dynamically rebasing the outstanding amount of money: the number of cryptocurrency units in every digital wallet is adjusted instead of each single unit changing its value,". Some authors such as Koning (2016) look at the emission of a cryptocurrency by a central bank.

2.1. Regulatory Responses to Cryptocurrencies across Countries

This section adopts a region-by-region approach to delineating the responses of national (and supranational) governments to bitcoin and other cryptocurrencies. Note: all analysis presented below was initially prepared in November 2016, and updated in February and September, 2017 to reflect important country changes; however, the list is subject to many alternations, often of a sudden nature, with the passage of time.

North America: Bitcoin is legal in Canada, Mexico and the United States. In the United States, the Treasury has classified bitcoin as a convertible decentralized virtual currency, while the Commodity Futures Trading Commission has classified bitcoin as a commodity, while the IRS taxes bitcoin as a property. In Canada, Bitcoin is treated as an 'intangible' under the Personal Property and Security Act, and in the province of Quebec it is treated under the MSB Act. Mexico intends to regulate Bitcoin under La Ley Fintech.

South America: several countries including Bolivia (2014) and Ecuador (2015) have made Bitcoin illegal. Other countries such as Brazil, Chile and Colombia do not regulate it under legal code. In Argentina, Bitcon is considered 'money' but not legal tender, and is treated as either a 'good' or a 'thing' under Argentine Civil Code.

Middle East & South Asia: Bitcoin is not banned, but it is discouraged in Jordan, Saudi Arabia, and Lebanon. In Israel, its taxation treatment is that of 'taxable asset' as opposed to 'currency' or 'financial security'. Bitcoin is explicitly banned in Bangladesh. Trading in Bitcoin is not banned in Pakistan, but the Federal Board of Revenue is investigating it for tax evasion. In India, it is neither banned nor discouraged, and there are no plans to regulate it, according to the Reserve Bank.

East Asia: China has brought bitcoin regulation into the popular press with its ruling on exchanges. In China, private persons can hold bitcoin but financial companies can not. The People's Bank of China (PBOC) has issued rulings in 2013, 2014, and 2017 with respect to banning, regulating, or restricting exchanges, but the final verdict is not out on this matter. In Japan, bitcoin is recognized as 'a means of payment that is not legal currency', and in 2017, the Japanese government officially recognized bitcoin as a method of payment. Bitcoin is not currently regulated in South Korea, but illegal activities through Bitcoin are prosecuted. In Taiwan, bitcoins can be purchased at kiosks, but warnings have been issued of the high risk of

bitcoin due to non-guarantee of conversion by any monetary authority. There are no regulations with respect to Bitcoin transaction or possession in Thailand, Indonesia, Vietnam, Philippines, or Singapore.

Europe: The EU has been comparatively leger de main vis-a-vis cryptocurrencies, and Bitcoin is indeed legal in the EU. There is no specific legislation on the status of bitcoin as a monetary device. However, the sales tax (VAT/GST) is not transposable to conversion between fiat currencies and bitcoin. For taxation purposes (see also budget, tax and revenue discussions in Chohan 2017a, 2017b, 2017c), the tax vehicles still apply to transactions made in bitcoins.

In October 2015, the Court of Justice of the European Union ruled that exchanging traditional currencies for bitcoin is exempt from VAT because bitcoins should be treated as a means of payment. For the ECB, regulation pertaining to the traditional financial sector cannot apply as there are no traditional financial actors, and it classifies bitcoin as a "convertible decentralized virtual that it was not in its power to ban virtual currency use in the same way that it was not in its power to ban the internet. In South Africa, a 2014 position paper stated that virtual currency had no legal status or regulatory framework.

Oceania: The Reserve Banks of Australia and New Zealand have both decided not to penalize the use of Bitcoin, and in Australia bitcoin is now treated 'just like money', while in New Zealand there is no objection to bitcoin as a 'store of value'.

In sum, there are many different attitudes and approaches to Bitcoin around the world, from outright prohibition to 'no objection' rulings. Their tax treatment is very different in various countries. The situation is likely to evolve considerably in the next 2-3 years, and regulators appear to be several steps behind the transacting users. The possibility of catastrophic price declines and losses of value, not guaranteed by a monetary authority, continues to loom large. Future research, particularly on the legality across national jurisdictions vis-a-vis Bitcoin, therefore has much scope of inquiry going forward.

2.2. Bitcoin

Bitcoin is a paying method introduced in late 2008 by the pseudonym Satoshi Nakamoto: the system was peer reviewed by the computer scientist, mathematician and cryptographer Hal Finney, worldwide known for his revising job on the encryption program Pretty Good Privacy (PGP) developed by Phil Zimmermann in 1991 the program is used to protect data and communications in e-mail: it guarantees a very strong level of privacy (comparable to that used by the military corps) by 128 bits encryption keys.

Since at that time, American regulation has considered keys larger than 40 bits as "munitions", and in 1993 Zimmerman was put under criminal investigation for having exported PGP without the required license. For this reason, contributors like Hal Finney

remained anonymous until the investigation was closed in order to avoid any criminal law consequence.

The first transaction ever was made in January 2009 between Satoshi and Hal, who later declared he had never met Satoshi or had had any clue about his identity. The transfer was a successful practical application of the principles enunciated by May (1988) and the beginning of a new adventure that would have change the boundaries of law and economics.

The system is based on a distributed ledger technology consisting of a data structure that records blocks of data cryptographically linked to each other. The data structure is denominated "blockchain" and is managed by a peer-to-peer network, an Internet architecture where every node has the same capabilities and is able to perform the same action as the others, even though some difference may be related to the effective hardware and connection capabilities.

The above considerations should be restated in the light of Bitcoin's technical structure. The production process, denominated "mining", sees all the peers of the network (taking the name of miners) competing for adding new blocks to the chain. Transactions are propagated in the network by peers: miners collect those with best prices, composing the candidate block they wish to add to the chain. The second step consists in applying a Hash algorithm (MD or SHA class) to the block, preparing for the calculation of the proof-of-work. This activity consists in adding a random number named "nonce" to the block and then calculating the hash again in a way to obtain a string opening with a given number of bits set to zero.

The operation is quite difficult since the hash digest changes evidently with even the smallest change in the text subject to the procedure. Furthermore, this variation is not predictable, so the only way to calculate the required digest is operating at brute force, making the process computationally quite expensive. The first miner finding the required hash wins the competition and attaches his candidate block to the chain: the new block is confirmed after 5 other blocks are attached after it, making the transactions it contains 6 blocks deep.

The system is projected in a way to make computational difficulty in the proof-of-work proportional to the computational power used in the network (measured in hash rate per second) so that block production remains stable in time at the rate of 1 block every 10 minutes. This lapse of time is conventionally set in order to avoid collisions of winning blocks and subsequent forks of the chain. In fact, network nodes work in an independent way, so it may happen that two different miners achieve the proof-of-work requirement and each of them manages to link his candidate block to a local copy of the blockchain.

This will create a fork where two different branches of the chain will proceed independently from each other. Peers may not be immediately aware of this situation and therefore keeping on working on the two different chains making them quite long: when the situation is

propagated all over the network, the longest chain overcomes the shorter one, thus making several former winning blocks unchained and leading their transaction to be processed once again.

The process we have described above makes it clear to understand the reason why in moments when market value is very high and several operations take place, transactions can get stuck into the network with a delay of nearly 24 hours for the payments to be properly confirmed.

3. Method

We analyzed daily returns of Bitcoin from January 1, 2013 until October 25, 2017 totalizing 248 weeks. We chose to start in 2013 because Chohan (2017d) considered that 2013 was the year that Bitcoin had grown in volume to the point of causing encumbrances to clearinghouses and 2013, and as seen in Figure 1, it was the first time that Bitcoin presented a huge price increase from US$13.3 on January 1, 2013 to US$ 1,047.98 on December 3, 2013.

The first step was to verify the average return in each day of week and apply a Student's t-test to examine the statistical significance of price differences .

The second step was to test if the calendar time hypothesis is correct and if the expected return for the weekday that has different average returns found in the first test also has different expected returns for the other days of the week, using the regression model proposed by French (1980) that is,

$$R_t = \alpha + \beta_1 D_{1t} + \beta_2 D_{2t} + \beta_3 D_{3t} + \beta_4 D_{4t} + \beta_5 D_{5t} + \beta_6 D_{6t} + \varepsilon_t \qquad (1)$$

where R_t is the weekday that we test if the return is different and D_{1t} to D_{6t} is the return of the other weekdays.

If the return in the weekday tested is different, then the α value is to be statistically significantly different from zero.

4. Results

The difference among the returns of each weekday is illustrated by the histogram of these returns shown in Figure 2. For all weekdays the returns are mostly in the positive region. Monday is the weekday with more positives returns (60,56%) and Wednesday and Saturday are weekdays with positive returns (51,00%) only slightly higher than negative returns.

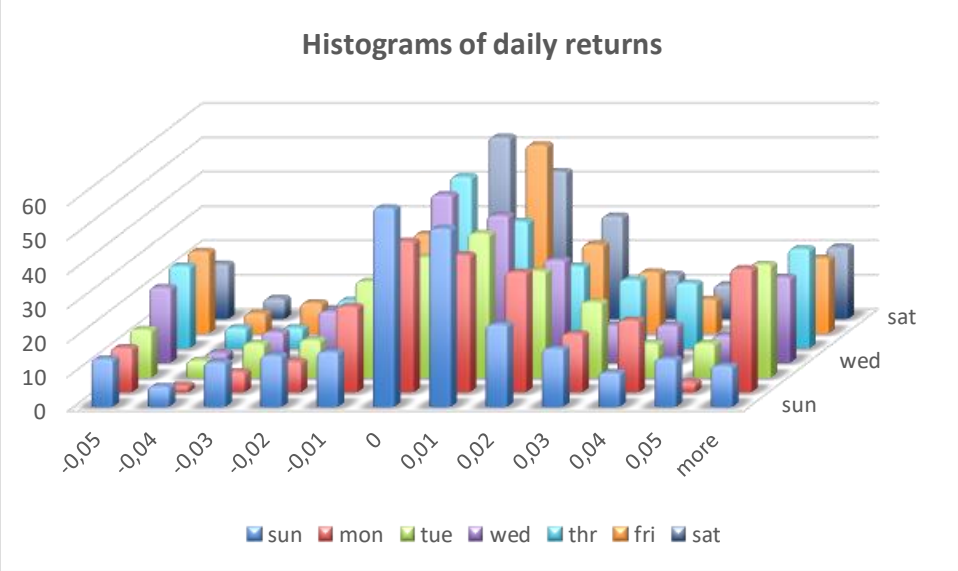

Figure 2: Histograms of daily returns

The histogram shows us that Monday has more higher returns and less lower returns than other days. The beginning of the week (Sunday until Tuesday) usually has less lower returns and the end of the week (Wednesday until Saturday) usually has more lower returns.

These higher returns on Monday is contrary to what occurs in the other markets, but it is confirmed by average returns in this context. We found a higher return on Monday, that presented an average return of 1.18% as presented in Table 1.

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
average daily return	0.17%	1.18%	0.69%	0.16%	0.65%	0.09%	0.25%

Table 1: average daily return

The day with the second-largest returns was on Tuesday, which had returns slightly more than half that observed on Mondays. In Table 2 we present the p-value of Student's t-test between each weekday. A strategy of buy at the opening on Monday and sell at the closing on Tuesday generates a return of 1.97% per week which equates to an annualized return of 175.4% per annum. This average return is smaller than the average weekly return of 2.42%.

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Sunday	1.0000	0.0062***	0.1500	0.9663	0.2656	0.7708	0.8191
Monday		1.0000	0.2638	0.0318**	0.2441	0.0058***	0.0149**
Tuesday			1.0000	0.2503	0.8836	0.1167	0.2337
Wednesday				1.0000	0.3501	0.8588	0.8361
Thursday					1.0000	0.2067	0.3645
Friday						1.0000	0.6296
Saturday							1.0000

Table 2: P-value of Student's t-test between weekdays returns

As we can observe in Table 2, the only weekday that present significant difference between other weekdays is Monday, whose average return is statistically significantly different from those of Sunday, Wednesday, Friday and Saturday.

However, contrary to what has been found in previous studies in the stock market and treasury bill market, we found *above-average* returns on Mondays.

We run the regression model using the Monday returns as dependent variable to test the hypothesis that Monday return is significant different, as shown in Table 3.

	Coefficient	*Std Error*	*T-Statistic*	*p-value*	
const	0.0109106	0.00304708	3.581	0.0004	***
Tue	−0.00973035	0.0655457	−0.1485	0.8821	
Wed	−0.0425173	0.0529856	−0.8024	0.4231	
Thr	0.138155	0.0550038	2.512	0.0127	**
Fri	0.0512957	0.0722152	0.7103	0.4782	
Sat	0.0488179	0.0829578	0.5885	0.5568	
Sun	0.0414305	0.0912900	0.4538	0.6504	

Mean dependent var	0.011901	S.D. dependent var	0.046987
Sum squared resid	0.521593	S.E. of regression	0.046619
R-squared	0.039634	Adjusted R-squared	0.015624
F(6. 240)	1.650768	P-value(F)	0.133955
Log-likelihood	410.3138	Akaike criterion	−806.6276
Schwarz criterion	−782.0619	Hannan-Quinn	−796.7373
Rho	−0.139200	Durbin-Watson	2.254131

Table 3: Regression model with Monday return as dependent variable

We found a positive value significantly different to zero for the constant, indicating that the returns on Monday are above the average, which confirms the hypothesis based in the observation of the average daily return.

5. Conclusion

This paper examined the process of generating Bitcoins returns under the calendar time hypothesis. This market works continuously, 24 hours a day and 7 days a week, and we sought to assess what effect, if any, that could have on the returns as categorized by days. In doing so, we would revisit a long-regarded inefficiency of markets, but through a new lens of cryptocurrencies, which led to new insights into the direction of returns in the anomalous day (Monday), as yielding higher returns rather than the lower returns in other markets.

During the period studied from 2013 until October 2017, the daily return of Bitcoin on Monday was significantly different from other days. The returns on Monday for Bitcoin are above average, which denotes evidence of market inefficiency.

Although there is an inefficiency, this does not necessarily allow investors to take advantage of it, because there isn't any day with negative returns what would allow investors to devise a strategy to sell and buy during the week. As all average returns are positive, the best strategy would be to have bought in January 2013 and to have kept Bitcoin until October 2017.

Bitcoin continues to garner heightened academic and practitioner interest, and its price is the subject of much fervent debate around the world. As such, the area is likely to constitute an important part of research on financial markets going forward, particularly if cryptocurrencies continue to gain large numbers of investors and adherents with the momentum that they have in the immediate past.

With that in mind, future research should examine if strategies with other cryptocurrencies could generate substantial returns as well. There is also significant scope to explore the regional, national, and supranational reactions to Bitcoin prices, regulation, investment, exchange, protection, and oversight. Looking back through that lens, there is also substantial scope to deploy the lens of Bitcoin to address longstanding problems in domains including financial markets.

Our paper is but one effort in that regard, revisiting the Monday Effect in financial markets, and finding that it is in fact a series of *higher returns* that occurs on Mondays, which raises new questions about the impact of such a market inefficiency as being manifested differently in the case of cryptocurrencies, with higher returns instead of the longstanding observation of low returns. Future research will find such deployment of cryptocurrency lenses to longstanding quandaries particularly fruitful as an avenue of investigative inquiry.

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