BITCOIN AND INTEREST RATES:

A THESIS

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By

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Bitcoin and Interest Rates

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Abstract

Bitcoin has evolved from an online token relegated to the fringes of society into a major player in modern financial markets. Bitcoin annual returns were the highest of any asset over the last decade, and it seems that it will not be returning to the fringe anytime soon. Many investors however are unwilling to invest or include the token into their portfolios and strategies due to the lack of understanding regarding its niche in financial markets. The purpose of this paper is to examine Bitcoin's relationship to real interest rates, gold prices, unemployment rates, and other variables in an attempt to shed light on how this asset correlates with the market at large. This was carried out using two separate multiple linear regression models which indicated statistically significant positive correlations between Bitcoin price and interest rates.

KEYWORDS: (Cryptocurrency, Bitcoin, Interest Rates)
JEL CODES: (E00, E40,C87)

ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED
UNAUTHORIZED AID ON THIS THESIS

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Peter F. Schmidt

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ACKNOWLEDGEMENTS

I would like to dedicate this thesis to my parents who have always worked so hard to support me throughout my education.

I also would like to thank my thesis advisor Dr. Menelik Geremew for his amazing guidance over the last few months.

Introduction:

The purpose of this study is to contextualize bitcoin in the context of other established financial assets by determining the relationship between Bitcoin price, interest rates, gold prices, oil prices, and unemployment rates. The construction of a model based on real interest rates will demonstrate the statistical relevance of real interest rate fluctuation on bitcoin price. Understanding this relationship will help individuals and institutions better understand how Bitcoin price will react to market conditions which in turn can help investors include this burgeoning asset in their strategies. Through the comparison of BTC and real interest rates we can better understand if BTC does have the characteristics which would warrant its nickname "Digital Gold". If a model using real interest rates is statistically significant it would help clarify how digital currencies interact with changing interest rates. A negative correlation gives further credence to the potential of bitcoin as a form of "digital gold", while a positive correlation would provide yet more data for the Gibson Paradox. Understanding the interplay between bitcoin value and the aforementioned independent variables helps investors understand how it can be included in their investment strategies. This would allow investors to utilize bitcoin as an alternate hedge against the eroding real wealth of dollar savings.

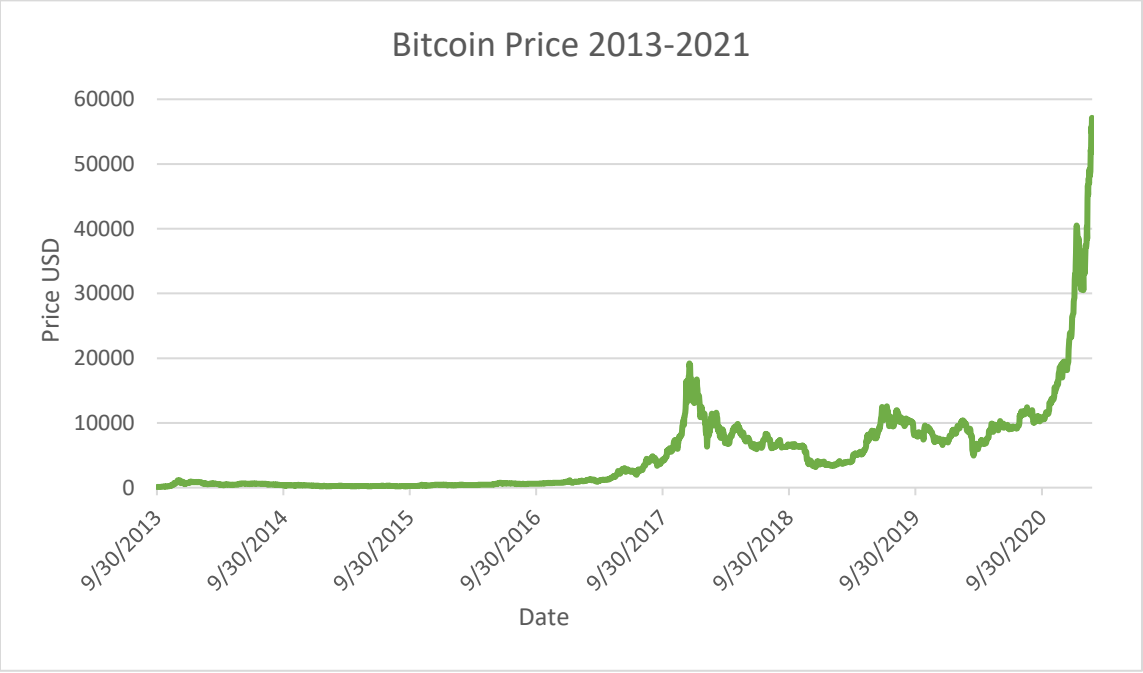
The cost to individuals and businesses of saving in terms of dollars has increased significantly since the abandonment of the gold standard and the recent massive expansion of money supply. The separation of gold from the dollar removed the burden of money supply and base value being tied to tangible reserves. This has allowed central banks to extend seemingly limitless lines of credit and create large volumes of currency to promote economic expansion and GDP growth. However, the consequences of fiat currency are numerous, and these externalities can be observed all over the world.

Among the unfortunate drawbacks that have been observed, there is evidence that increases in GDP growth catalyzed by modern monetary policy have brought with them increased income inequality and in some cases reduced standards of living. (Baligh & Piraee, 2013) These drawbacks underscore the importance of investment as a method to protect oneself from currency devaluation at the hands of centralized modern monetary policy. The potential devaluation of value present in fiat currency is a powerful catalyst for driving investment in a variety of alternative appreciable assets. The theory that unlimited credit could hamper the purchasing power of those saving in terms of dollars was forecasted by former Federal Reserve Chair Alan Greenspan, "The abandonment of the gold standard made it possible…to use the banking system as a means to an unlimited expansion of credit. There is no safe store of value…no way for the owners of wealth to protect themselves… [it] is simply a scheme for the confiscation of wealth. Gold stands in the way of this insidious process. It stands as a protector of property rights". (Greenspan, 1966) The adoption of fiat currency therefore increases the risk and cost of saving in terms of fiat. Therefore, investment in assets poised to outperform in the context of modern monetary policy is of crucial importance to both institutions and individuals in order to mitigate the negative effects of modern monetary policy.

The primary goal of investment is to realize positive returns while mitigating risk through a careful selection of assets. Given the drawbacks of fiat currency, investments with high annual returns are crucial for the preservation and creation of real wealth. As a result of these risks institutions and individuals alike are always on the lookout for investment opportunities that have the potential to generate outsized returns relative to the rest of the market. Historically these investments are in established asset classes including domestic large or small-cap stocks,

commodities like gold and oil, and real estate investment trusts. The past decade however has been dominated by a surprising newcomer in financial markets, Bitcoin.

Fig. 1



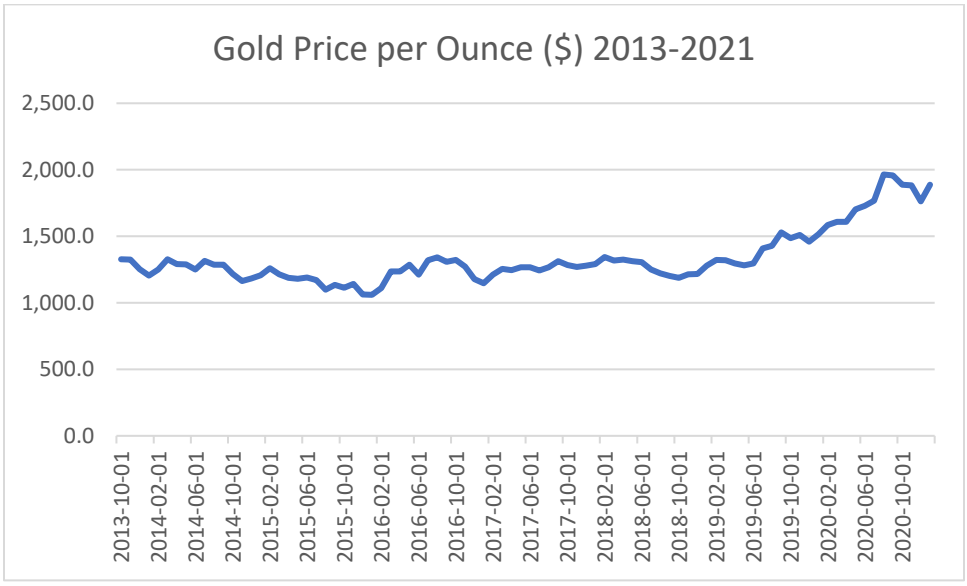
Source: Coindesk.com

The oft maligned and consistently volatile digital asset has been stealing headlines and market share alike. The staggering outperformance of Bitcoin relative to the market has piqued the interest of wealth managers and investors. The data collected for this project begins on September 30th, 2013, from that date up until when data collection for this project was ceased on February 21st, 2021 the value of one bitcoin had increased a mindboggling 47,493.5%. These gargantuan returns present a compelling alternative store of value to fiat currency and traditional financial assets, yet its niche in the greater context of global markets remains somewhat unclear.

The meteoric rise in bitcoin price has occurred in concert with many interesting developments in financial markets. Over the past eight years gold prices have remained fairly

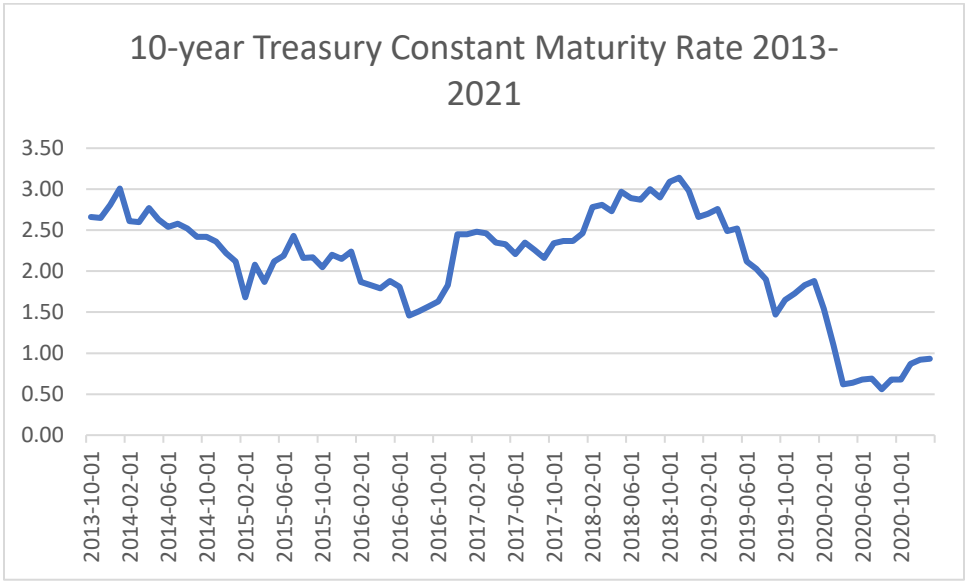
stagnant up until 2018 when prices began to rise more steadily. This coincides with a marked decrease in the rates on 10-year treasuries which fell in 2018 and have continued that trend since.

Fig. 2



Source: gold.org

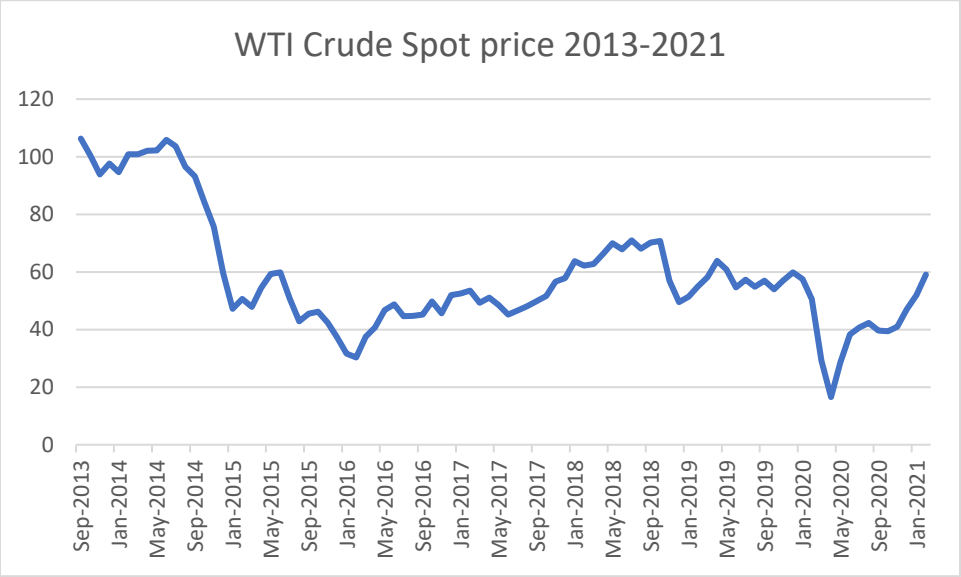
Fig. 3



Source: fred.stlouisfed.org

Oil prices trended down during the same time window with small rallies from 2016-2018, in similar fashion to the rates on 10-year treasuries.

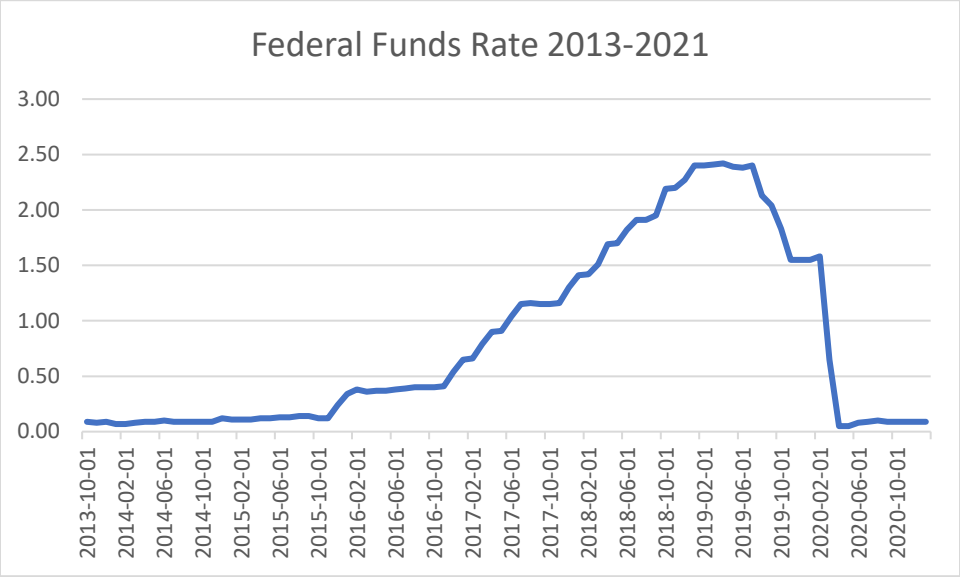
Fig. 3



Source: eia.gov

These market trends are in large part a product of the complex monetary policy environment which has dictated much of the last decade. Following the 2008 financial crisis, monetary policy became a crucial tool for the federal reserve to stimulate financial markets. The Federal Reserve set low rates and provided ample liquidity to fuel a recovery. This aggressive use of monetary policy has acted as a support system for markets while reducing the opportunity cost of capital. The role of monetary policy in supporting markets was further highlighted following the outbreak of the COVID-19 pandemic. In order to combat the economic effects of the pandemic the federal reserve enacted a myriad of programs including swap agreements, stimulus packages, debt purchases, and of course lower rates. As shown below the federal funds rate was very close to zero from 2013 to 2015. This was followed by an increase in the overnight borrowing rate from 2016 until 2019 when it fell to 1.5 percent. It persisted at this level until the onset of the COVID-19 pandemic which caused the Federal Funds Rate to collapse back to nearly zero. (Sarker 2020)

Fig. 4



Source: fred.stlouisfed.org

The role central bank monetary policy has played in supporting markets over the last decade is profound. Bitcoin finished the decade as the best performing asset which begs the question, how do these price movements and factors relate to bitcoin?

This study explores the understudied relationship between real bitcoin price and a variety of established asset classes and macroeconomic indicators. Cryptocurrencies appear to be here to stay, and for investors to be able to take advantage of the prodigious returns it is crucial that bitcoin is contextualized relative to the rest of the market. An understanding of these relationships would allow investors to understand how to employ this asset in their investment strategies going forward.

Research Question:

Can a corollary relationship be established between bitcoin price action and various macroeconomic variables?

Research Hypothesis:

H_0: $B_1=B_2=B_3=B_4 = 0$

H_1: at least one slope coefficient $\neq 0$

I hypothesize that a model for real bitcoin price which uses real interest rate, real gold prices, real oil prices, and unemployment will be significant enough to reject the null hypothesis. I expect the same result for an identical model which uses federal funds rate instead of real interest rate.

Literature Review:

Bitcoin Value:

Understanding the existing research into bitcoin was crucial for framing this project. An early analysis of bitcoin by Starry Peng at the University of Pennsylvania posits that much of bitcoin's appeal as an asset is largely due to the fixed supply which indicates increased value over time. The fixed supply of bitcoin is due to the proof of work-based mining system which increases the difficulty of mining and decreases the rewards as time progresses. This intrinsic computational scarcity is important for the classification of bitcoin relative to other assets. Peng notes that from the outset this system was designed to electronically mimic the scarcity and mining difficulties of gold. (Peng, 2013) The connection many draw between bitcoin and gold finds its routes in the very earliest codebase for the coin. This indicates that this relationship between the two assets was a driving force behind the architecture of the codebase. However, modeling the scarcity and supply after finite natural resources like gold is not sufficient evidence that bitcoin behaves like "digital gold".

While much of Peng's research is quite prescient, her discussion of what draws buyers into the network is overly simplistic. The factors that drive interest in bitcoin vary significantly by market segment and are much more complex than just scarcity. Wingreen, Kavanaugh, Ennis, and Miscione published their research regarding the different value systems that drive bitcoin value by market segment. This nuanced investigation into personal and subjective value drivers utilized Q methodology and sorting to draw conclusions from their data. They found that there were five primary market sectors who all had completely different factors which drew them to bitcoin. In many cases these value drivers contradicted each other. For example, one segment is

drawn to the decentralized nature of the asset while another ranked that very same lack of centralization as a major negative. (Wingreen, Kavanaugh, Ennis, et al 2020) This research has interesting implications regarding what brings buyers to bitcoin, but the subjective nature of the analysis and the personal focus does little to illustrate bitcoin's position as an asset in the greater economic context.

Event-Reaction Literature:

Event based analysis provides great answers to some of the questions left unanswered by the aforementioned research. An event-based analysis carried out in this past year sought to compare various cryptocurrency price reactions to other established assets following watershed global events. The selected events were Brexit and the 2016 presidential election in the United States. This was carried out by establishing ten-day event windows, five days before the event and five after. Then the percent changes in price were recorded and compared for the assets. The event analysis indicated, when compared to gold and silver prices, "Bitcoin tracked closely to the changes in commodity values as far as the direction (but not magnitude) of changes after the Brexit vote." (Schaub 2019 p 11) The difference in magnitude is attributable to the tremendously unwieldy volatility of bitcoin, a persistent problem for researchers. Volatility aside, the directional tracking with store of value commodities gives more credence to the digital gold classification. Despite the undeniable macroeconomic consequences of these events this methodology is based on primarily political events which relegate macroeconomic implications to the second order of outcomes.

A more directly applicable event-based analysis was provided in the *European Journal of Finance* by Corbet, Larkin, *et al.* By utilizing a more robust statistical methodology than Shaub and focusing on news releases directly related to macroeconomics, the researchers can provide

much better event analysis for bitcoin. The specific news releases selected related to gross domestic product, durable goods index, consumer price index, and unemployment. The results yielded indicate that bitcoin is treated by many investors as a hedge, reacting positively to negative announcements. (Corbet. Larkin, *et al* 2020) Not all research can find such useful results, however. Pyo and Lee published their work tracking btc price with Federal Open Market Committee announcements in *Finance Research Letters.* Utilization of a regression model was used by the researchers. Despite careful experimental design, no clear or significant relationship was established. (Pyo, Lee 2019) Bitcoin's relationships to events indicates both a connection to commodities and its use by investors as a hedge. Direct comparisons between data sets with longer time horizons than those used in event analysis, however, remains a burgeoning yet underserved corner of research required to understand bitcoin in a greater context.

Support Vector Machine Learning:

A creative method for research methodology published in the *Journal of Behavioral and Experimental Finance* is the use of support vector machine learning to analyze time series data. This method is employed to create predictive models. The relationship between bitcoin price action and the global financial stress index was not positively correlated in the slightest. This is further indication that bitcoin could function as a hedge against uncertainty in markets. (Aggarwal 2020) These findings are reiterated by Matkovskyy, Jalan, and Dowling in the Quarterly Review of Economics and Finance. Through the employment of EWMA models for the covariance matrix, bitcoin returns were compared with economic policy uncertainty. The results indicated that when economic policy uncertainty rises Bitcoin volatility falls in US markets. These results were statistically significant. (Matkovskyy, 2020)

Interest Rates and Asset Prices:

Classifying new kinds of assets requires careful research into a wide array of relationships. One incredibly important macroeconomic indicator that influences price action for nearly all established assets is the real interest rate. The importance of research centering on these relationships is highlighted by Irving Fisher in his 1930 treatise about interest rates. He explains, "No problem in economics has been more hotly debated than that of the various relations of price levels to interest rates. These problems are of such vital importance". (Fisher, 1930, p. 399) There is a gap in the existing research surrounding bitcoin's relationship with interest rates. Interest rates have a major effect on real asset prices, as proven by Barsky and Bogusz of the Federal Reserve Bank of Chicago. Multiple models were employed in their methodology, namely they employed the simple Gordon formula and the log linearized dynamic Gordon model to derive the influence of interest changes on an asset. (Barsky, Bogusz, 2014) Interest rates are increasingly important moving forward. They have been persistently low for some time and will continue to be crucially important for determining asset performance in the years to come. (Sarker, 2020). It can then be deduced that research exploring this relationship would provide great value to individuals and institutions focused on investment.

Gold Research as Proxy

In order to compose an effective experimental design to examine the real interest rate and bitcoin relationship one must refer to previous research. Unfortunately, there is almost no direct research on the topic, therefore the best sources to inform the design of this experiment are provided by research looking at the real interest rate and gold relationship. The relationship between bitcoin and gold, both in terms of asset behavior and supply structure, is evident in (Matkovskyy, 2020), (Aggarwal 2020), (Shaub 2019), and (Pyo, 2013). Another more direct analysis is provided by

Konstantinos Gkillas and Francois Longin. They focused on understanding the interplay of bitcoin and gold during high volatility environments. Multivariate extreme value theory was used to model the tail dependence structures and it was shown that, “Such evidence shows that bitcoin can be considered as the new digital gold”. (Gkillas 2019, p 24) This conclusion is based on the volatility response of these assets and further fortifies the theory that bitcoin is digital gold, however the crucial relationship to real interest rates remains unexplored.

The robust research on gold price and interest rates yields a fascinating wealth of research on the gold real interest rate relationship as well as several great methodologies for testing that relationship with other assets. Gold has exhibited an inversely proportional relationship to real interest rates in many time periods. From 1972 to 1982 gold underwent a very volatile decade, however still managed to exhibit an inverse relationship with real interest rates. (Gulati & Mody 1982). This relationship is further clarified by Peter Abken whose work was published by the Federal reserve bank of Richmond. (Abken, 1980).

More recently Adam Abdullah explored this relationship and concluded that gold price can be changed by changing real interest rates. Abdullah observed the relationship between interest rates and real gold prices. His study additionally observed how interest rates and other commodity and asset price levels were interrelated. Over 40 years of data was compiled for this study and the conclusion was a significant inverse relationship between real prices and real interest rates. Additionally, Abdullah asserts that changes in price levels positive or negative are a response to changing interest rates. This highlights the importance of analyzing the empirical relationships which are the underlying drivers of price action. (Abdullah, 2013)

A variety of regression techniques have been employed by researchers to test the statistical validity economic relationships. The Journal of Applied Sciences published a study by Ismail,

Yahya, Shabri et al, that utilized multiple linear regression with several variables to try and understand the major influencers of gold price movements. (Ismail, Yahya, Shabri, et al, 2009) This study differed from both (Abken, 1980) and (Gulati and Mody, 1982) due to the employment of a linear regression model. The use of regression models is also employed by Adam Abdullah who has produced several excellent studies on the topic of gold in the greater macroeconomic context.

The most helpful gold research for this project was published in the International Journal of Economics and Finance in 2015. Authored by Adam Abdullah of Al Qasimia University and Mohd Jaffri Abu Bakar of University Sultan Zainal Abidin. They seek to create a model for the price of gold in relation to interest rates that would benefit wealth managers and investors going forward. First full populations of data were gathered on nominal gold prices, consumer price index, and nominal yield for 3-month treasuries. They then divided nominal gold price by the CPI for the corresponding period and subtracted cpi from the nominal rate with the same method. This yielded real prices for all variables which were then analyzed using a linear regression. (Abdullah and Bakar 2015)

Economic research regarding bitcoin is somewhat thin due to both the relative youth and obscurity of the asset and as a result there are numerous important correlations which have yet to be explored. The research covered above indicates that scholarship regarding the relationship between real rates and bitcoin price is a very important one for investors to understand so they can feel comfortable creating investment strategies which employ bitcoin. The problem is that little research exists regarding this question and therefore research into the validity of the gold and bitcoin relationship is required to find out whether we can use research focused on gold to inform this study. The interest rate and gold relationship has been a consistent topic for economic

researchers, and as bitcoin matures as an asset class, it is clear research into its interest rate relationship ought to become more common.

Methodology:

Data Description: The data used in this analysis were sourced from a variety of databases in order to compile a full population of datapoints which can be used to analyze the correlations between bitcoin price and various indicators. The primary relationship under examination is that of real interest rate and real bitcoin price, however, WTI crude oil prices, unemployment, and gold prices are also variables.

Bitcoin price data is crucially important to this analysis and as such reputable and accurate data is of the utmost importance. I sourced the bitcoin price data from coindesk.com, a reputable repository for price data on cryptocurrencies. This was my selected source due to the precedent set by past researchers who have utilized this source in the past. (Corbet, Larkin, et al, 2019)

The data for WTI crude oil prices was sourced from the United States Energy Information Administration. EIA.gov represents the preeminent database for energy data in the United States which made it the clear source for this data. WTI crude prices were specifically chosen over other oil price metrics due to the widespread use of this metric in the United States. Additionally, this was used by Shiller to understand the relationship between rates and oil prices indicating its use in econometric analyses. (Shiller 2007)

Gold price data was important as well and I selected to use price per ounce in dollars. The Gold price data was sourced from gold.org. and the variable was selected because of the established relationship between the two. (Gkillas & Longin, 2019)

The remainder of the data was sourced from the Federal Reserve Economic Data service offered and maintained by the St. Louis Federal Reserve Bank. Fred.stlouisfed.org provides excellent

and up to date macroeconomic datasets, which is why it is such a crucial source for the datasets used in this analysis. The specific datasets sourced from Fred are as follows: Consumer price index (CPIAUCSL), Unemployment rate (UNRATE), and the 10-year treasury constant maturity rate (DGS10). Each of these were carefully selected for inclusion. The consumer price index data was necessary because it is used to calculate real interest rates and real price levels for bitcoin, gold, and oil. The unemployment rate was included due to the correlation uncovered by Corbet and Larkin in their event-based analysis. (Corbet & Larkin, 2020). The gentle correlation between the two, while not spectacular, was among the most statistically significant in the whole study.

As for the data for interest rates I have elected to examine two different measures of interest rates in order to create and compare to different models in order to understand which has a more significant relationship to bitcoin price. The first measure used is the 10-year treasury constant maturity rate. CPI for corresponding time periods was then subtracted from the 10-year rate to find the real interest rate. Abdullah and Bakar use a similar strategy involving rates on treasury securities and consumer price index as the basis of their interest rate measures, which yield excellent empirical research. (Abdullah & Bakar, 2015) The second model is nearly the same in construction, however, it uses the federal funds rate instead of the real interest rate previously mentioned. The impetus for this decision is inspired by the scholarship of (Pyo & Lee 2019). The federal funds rate demands examination and inclusion due to its close relationship with the actions of the federal reserve, monetary supply, and the discount rate.

Method and Model:

The method for comparison employed in this study is multiple linear regression. Linear regression is a tried and tested method for evaluating the relationship between prices, interest rates, and other economic variables. Multiple linear regression has been employed successfully to prove the inverse relationship of real gold price and real interest rates in many pieces of economic research. (Ismail, Yahya, Shabri et al, 2009). Linear regression is also utilized in both (Abdullah 2013) and (Abdullah & Bakar 2015).

The model used is:

$Y=B0+B1X1+B2X2+B3X3+B4X4+u$

Where:

Y= real bitcoin price

X1= real interest rate (federal funds rate in second analysis)

X2 = real gold price (oz)

X3 = real Crude oil price (per barrel)

X4= unemployment

U= error term

Data Transformations: Many transformations to data inputs must be made to turn nominal values into real values. This model relies on comparing real prices to real rates, not nominal prices to nominal rates. As such Consumer Price Index is used to transform nominal prices into real prices and nominal rates into real rates. This strategy is employed by researchers using multiple linear regression to analyze real price and real rate relationships in prior econometric analyses. (Abdullah & Bakar, 2015)

In order to transform the interest rate (DGS10) into real interest rate the following is carried out:

$Rir = Ir – CPI$

In order to transform bitcoin, oil, and gld prices into "real" prices the following must be done for each:

RealBTC = BTC/(CPI/100)

Realgold = gold/(CPI/100)

Realcrude = WTIcrude/(CPI/100)

Once these variables are transformed, they can be regressed using the above model. The overall significance of these models will be analyzed using F tests. The R^2 values will be analyzed to understand the predictive capacity of the model. P values will be analyzed to assess the significance of each variable included in the model. An alpha of .05 is employed to measure significance.

Potential Analysis Issues: It is important to note that many of the problems surrounding econometric methodologies relating to bitcoin stem from the large amount of volatility. Bitcoin is very volatile relative to many of the other variables used for this study. In an attempt to lessen the noise of this hectic price action I have controlled for bitcoin price by month. Macroeconomic data such as interest rates and unemployment are significantly more stable than bitcoin price. Therefore, most regression models using daily price data are negatively affected due to the wild variance in values of bitcoin price relative to the independent variables in the model. Using less frequent data allows for cleaner analysis that focuses more on long term trends rather than short term volatility. By providing monthly price points which coincide with the macroeconomic data from the Federal Reserve, I hope to reduce the confounding potential of bitcoin volatility on my results.

Results & Discussion:

In this section I will analyze the results of both multiple linear regression equations in order to contextualize how the selected variables inform bitcoin price. Additionally, the overall statistical significance of both models will be examined in order to determine if there is caused to reject the null hypothesis. After both models are examined separately, I will compare the results of both and discuss the implications. Additionally, the statistical significance and relevance of each individual variable will be examined as well. The hypothesis applied to both models is as follows:

H_0: $B_1=B_2=B_3=B_4 = 0$
H_1: at least one slope coefficient $\neq 0$

Model 1:

Real interest rate calculated using 10-year treasury constant maturity rate.

Dependent variable: Real Bitcoin Price

Method: Multiple Linear Regression

Table. 1

Number of observations	88
F (4,83)	27.87
Prob>F	0.000
R^2	.573
Adjusted R^2	.552
Root MSE	1329.7

Table. 2

Variable	Coefficient	Std. Error	T-statistic	P value
Real Interest Rate	1630.399	608.088	2.68	0.009
Real gold	34.846	4.714	7.39	0.000
Real Oil	-97.217	29.745	-3.27	0.002
Unemployment	-317.654	92.761	-3.42	0.001
constant	-12559.6	2032.335	-6.18	0.000

The results of model 1 are sufficient to reject the null hypothesis. This was determined by conducting an f-test. The critical f value that fits the degrees of freedom for the model and the residual is 2.48 which lies well below the value of 27.87. This indicated that the overall significance of the model is greater than zero. This model is certainly functional for understanding certain facets of bitcoin price action.

The overall ability of this model to account for bitcoin price is demonstrated by the R^2 and adjusted R^2 values. These values help illustrate the goodness of fit of the model. The R^2 value is .573 and the adjusted R^2 value (which adjusts based on the number of independent variables) is .552. These values, while not astronomically high, do demonstrate the model's capability to predict a majority of bitcoin price points. The R^2 values indicate that the model is able to account for 57.3% of the variance in bitcoin price. This is a weak correlation, however given the short price history and high volatility of bitcoin, lower R^2 values are to be expected.

The significance of each explanatory variable is demonstrated by the t and p values. In the case of this model all of the variables are statistically significant at the .05 level which was selected as the alpha level for this regression. This alpha level represents a 95% confidence interval.

The coefficients on each term allow us to understand how each selected variable relates to bitcoin price within the parameters of this model. Real interest rate has a large positive coefficient which indicates a positive correlation with real bitcoin prices. Real gold prices also appear to be positively correlated with real bitcoin prices. Real oil prices and unemployment appear to be negatively correlated with bitcoin when this model is used.

Model 2:

Federal Funds rate

Dependent variable: Real Bitcoin Price

Method: Multiple Linear Regression

Table. 3

Number of observations	88
F (4,83)	38.59
Prob>F	0.000
R^2	.65
Adjusted R^2	.633
Root MSE	1207.7

Table. 4

Variable	Coefficient	Std. Error	T-statistic	P value
Federal Funds Rate	1054.93	202.776	5.20	0.000
Real gold	22.832	2.345	9.73	0.000
Real Oil	-19.362	15.621	-1.24	0.219
Unemployment	-95.231	98.553	-0.97	0.337
constant	-10501	1283.662	-8.16	0.000

Model 2 utilizes a different metric for interest rates which resulted in very interesting results. The first question that must be answered is whether or not this model is able to reject the null hypothesis. By conducting an f test and comparing the result to the f critical value we are able to reject the null hypothesis that there is no significance in the model. The f value yielded is 38.59 which is sufficient for rejecting the null hypothesis.

The proportion of variance explained by the model is demonstrated with both the R^2 and adjusted R^2 values which in the case of this model are .65 and .633, respectively. These values demonstrate the predictive ability of the model. These values indicate that the model is able to account for between 63 and 65 percent of variance in bitcoin price which is quite high

considering the volatile behavior of bitcoin The R^2 values demonstrate that this model is helpful for understanding some of the value drivers for bitcoin.

P values are used to understand the significance of each variable in the model. In the case of this model the p values are very interesting. Federal funds rate has a p value of zero which indicates statistical significance at the .05 alpha level. Additionally, real gold prices also have a p value of zero and are significant. Unlike model 1 however, both real oil and unemployment have p values much higher than .05 which indicates no significance.

The variables with significant p values both had positive correlations with bitcoin, just as in model 1. The coefficients on the Federal Funds Rate and real gold both indicate a positive correlation with bitcoin.

Discussion of Results:

The results of this analysis yielded many interesting takeaways regarding bitcoin's position in the greater economic context. Both models were able to provide clarity regarding bitcoin's relationship with interest rates and various established financial assets. Models 1 and 2 shared many similarities while also having many differences.

R^2 values are a crucial data output which help us understand the ability of a model to predict bitcoin prices. Interestingly model 2 which utilized the federal funds rate had a much higher R^2 value which indicates it is better able to predict and account for bitcoin price. Lower R^2 values are an expected part of any current research into bitcoin due to the high volatility and short time horizon of data available. Considering those constraints, the .65 value present in model 2 points to a fairly effective model.

A major difference between both models was the differences in p values between the variables in each study. In model 1 all variables had P values lower than the .05 alpha which indicated their validity in the model. In model 2 however only real gold and federal funds rate had p values lower than .05. This meant that in model 2 unemployment and real oil prices had little effect.

In terms of bitcoin's relationship with the included variables, the figures below demonstrate the general direction of the correlation. The first scatter plot represents all the variables in model 1 and the second accounts for the only remaining variable, federal funds rate.

Fig. 5

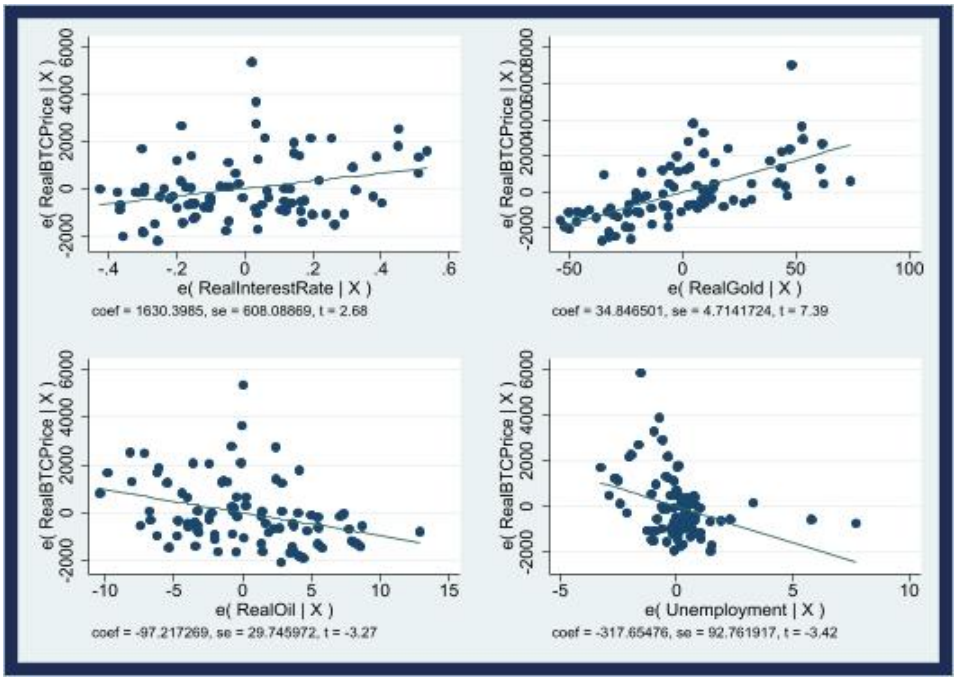
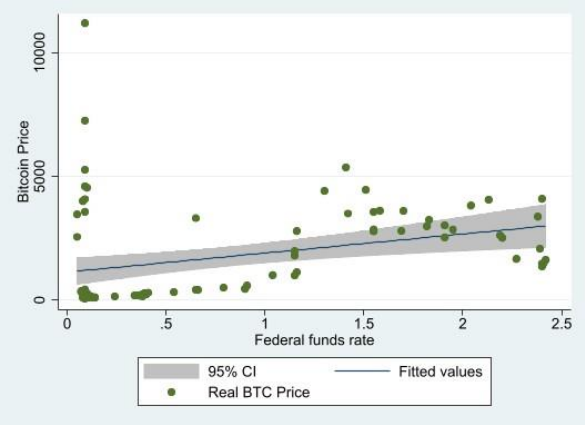


Fig. 6



These scatterplots in addition to the results of the multiple linear regression help to clarify the position of bitcoin in relation to various economic indicators and asset prices. In this study we observed a statistically significant positive correlation between real bitcoin prices and real interest rates. The same correlation can be observed in the next figure which shows a weak but positive correlation with the federal funds rate. This relationship is shown to be even stronger when context is applied the outliers near the y axis. Covid-19 caused the federal funds rate to fall to zero and during this time bitcoin price rose astronomically due to a myriad of factors including stimulus programs, unease, and major societal disruption, all of which drove capital inflows to bitcoin. (Chen, Liu, Zhao, 2020) This finding is a chink in the armor of the “Digital Gold” comparison which is often made in regard to bitcoin. The relationship with gold however is shown to also be a positive correlation which serves to support the claim to some degree. Real oil prices and unemployment were negatively correlated with bitcoin. The above figure however highlights that the data for unemployment and bitcoin is not a good fit. Additionally, model 2

found these values to be insignificant. In short, the results demonstrate weak yet significant positive correlations between bitcoin, gold, and interest rates.

Conclusion:

Bitcoin's massive annual returns have thrust it onto the mainstream with individuals and investors queuing up to invest in the young asset. This study sought to better clarify the relationship between bitcoin price, gold price, oil price, unemployment, and interest rates. Understanding how these variables relate to price action helps investors strategize and predict long run price patterns based on macroeconomic predictions. This study demonstrated that bitcoin price is positively correlated with interest rates. This was confirmed in both models 1 and 2 where bitcoin was significantly correlated with both the federal funds rate and real interest rate derived from 10-year treasury rates. The models used in this study also demonstrated a positive correlation with gold price. Unemployment and real oil prices were both negatively correlated, however the lack of significance in model 2 demonstrates the inability to conclude outright that there is a corollary relationship with these assets. Any examination of bitcoin will be fraught with many lurking problems which affect statistical analysis. The findings of this study were inconclusive in allowing us to completely confirm or deny the validity of the "digital gold" title. Despite this both models help to demonstrate how bitcoin behaves relative to interest rates and commodity prices, two very important relationships for understanding how this asset will behave moving forwards. The primary issues I found were the tremendous volatility and the short time horizon of available data. In short much more research must be carried out on bitcoin in order to fully contextualize its place in financial markets. Mark Kritzman, who wrote a seminal piece regarding the classification of asset classes asserts that in order for an asset class to be adopted

widely it must have “reasonable volatility” (Kritzman, 1999) The potentially unreasonable volatility of bitcoin remains a major hurdle in its global adoption into institutional investment strategies, however as more research is conducted adoption will continue to grow.

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