THE DYNAMIC RELATIONSHIP AMONG THE CRYPTOCURRENCY (BITCOIN), PHILIPPINE STOCK MARKET AND PESO-DOLLAR EXCHANGE THROUGH VECTOR AUTOREGRESSIVE ANALYSIS

Armstrong H. Tibay

School of Statistics, University of the Philippines Diliman, +639175303330, armstrong.tibay@yahoo.com

Joseph S. Ortiz

School of Statistics, University of the Philippines Diliman, +639187942650, jsortiz@up.edu.ph

Marius Dane C. Lucas

School of Statistics, University of the Philippines Diliman, +639954267761, mariusdanelucas@gmail.com

Abstract

Cryptocurrencies, most notably Bitcoin, had been rising in popularity lately. Bitcoin in particular has had a large increase in price from when it first came out and still stays at a relatively large value despite its recent drops. Since its introduction to the people, bitcoin invited people for a financial investment. The Peso-Dollar Exchange is one of the determinants of the country's economic status wherein studies were made that relates it to the Stock Market which is a significant factor in a country's economy. Due to the inevitable increasing influence of Cryptocurrencies and the possible relationship of exchange rate to stocks, it is important to determine its effects to Philippine stock market, a significant indicator of the country's economy. In this study, the researchers analyze the potential dynamic relationship between Cryptocurrencies, through Bitcoin, the Philippine Stock Market, using PSEi, and Philippine Peso-US Dollar Exchange Rate. In the results of the study, it was found out that Bitcoin closing prices and Philippine Peso-US Dollar Exchange Rate have an underlying effect on PSEi through the use of Vector AutoRegressive (VAR) Model.

Keywords: Vector AutoRegressive (VAR), Peso-Dollar Exchange, Philippine Stock Exchange, Bitcoin

1 Introduction

Monetary flow in the economy is variously changing and it can be reflected on the rise of the cryptocurrencies over the past few years. Those online cash are gaining the attention of the world since it started to acquire its popularity among the citizens.

The world's financial system is broken down, and the trust in the systems of the world, be it financial or political, is in all time low because of the fast developing technology. Further, the centralized banking system stress people with high fees and outdated processes. Because of these issues, a new form of decentralized (meaning no one had control over it) currency was invented. It would simply be peer-to-peer meaning, anyone can transact quickly, easily, and anonymously without incurring ridiculous fees and going through antiquated processes. This is called the 'Bitcoin'. (Comm, 2017)

Bitcoin, the most popular cryptocurrency originated last 2008 and the development was driven with the motivation to introduce electronic cash payments possessing other advantages of utilizing the physical cash (Berentsen & Scharf, 2018). With the given advantages of the Bitcoin, it may have a significant impact on the way that ordinary Filipino do commercial transactions. It is useful for OFW's who send remittances to the Philippines and according to BSP, 86 percent of Filipino household do not have a bank due to insufficient capital and proper identification requirements. Thus, the bitcoin can get the trust of the Filipino people as they can benefit from it. In fact, according to BSP Governor Nestor, Jr., "the Philippines already ranks third globally in terms of Bitcoin use." (Plaza, 2017)

However, with its popularity emerging across the globe, the demand for bitcoin has grown as people speculate for its future value. As a result, the demand for it has extremely grown, and so as its price. And with this, the bitcoin is now seen and has been bought as a financial investment, not for money to buy goods and services (Wolla, 2018). Bitcoin's excessive volatility is more consistent with the behavior of a speculative investment than a currency. It also imparts risk to any business that accept it for transaction, just like all other currencies. If bitcoin becomes wildly successful and displaces sovereign fiat currencies, it would exert deflationary force on the economy since the money supply would not increase in concert with economic growth since there is an absolute 21 million units that can ever be issued, with no possible expansion of the bitcoin supply after the years 2140 (Yermack, 2013)

Moreover, as the price of the bitcoin spiked up and so as its popularity, many people joined the hype in investing on it. De Martino, O'doherty, et al., (2013) studied why certain people get involved in this kind of investment, and according to their findings, humans try and understand

what someone else is thinking and to work out what they might do in the future. They found out that parts of human's brain that are responsible for evaluating other people's thoughts and feelings are also active when we make decisions to invest in a rapidly increasing valued asset. They call this the "Theory of Mind". People think that others are likely to buy into a particular asset, so they try and get in before them.

As bitcoin also became popular in the Philippines as a good investment, this in turn may have an impact on Philippine Stock Exchange. It was stated in an article from time.com that Bitcoin has a tangible connections to stocks. Due to sudden popularity and rise of cryptocurrency, Investors and companies jumped on the Bitcoin bandwagon. It was also stated by Jim Paulsen, chief investment strategist at The Leuthold Group, "If there's a collapse in Bitcoin, the direct financial impact won't be overwhelming, but it could set off a lot of fear and very radically alter people's mindset—which in turn could be damaging for stocks." Some companies even changed the model of their businesses with cryptocurrencies, and many investors were hooked in this trend (Lim, 2018). This may be a proof that there is a relationship between Bitcoin and the stock market. However, the there are few studies regarding the bitcoin and stock market prices relationship for the Bitcoin just new in 2013 and gained the people's attention at 2017(Arnold, 2018). Assuming that the bitcoin has a latent effect on the Stock Market, it is of great interest to study it has an effect on the Philippine Stock Exchange.

Further, it has always been observed that the Peso-Dollar Exchange Rate has an inverse relationship with the stock market, so that whenever Philippine stock exchange index rises or falls, the price of dollar in peso decreases or increases (Ong, 2017). Moreover, The Philippine Stock Exchange is considered as a significant indicator of economic performance of the country (Balaba, 2017) and thus investigating if there is an impact of bitcoin investment and peso-dollar exchange rate on Philippine Stock Exchange could give further insights whether bitcoin has a positive or negative effects in our economy in the long run and know how much the Exchange Rate affects the PSEI. It was suggested by Dornbusch & Fischer (1980) that stock price could be affected by changes in the exchange rates since it also affects the company or firm's earnings.

The study seeks to find the dynamic relationships among the Philippine Stock Exchange, Exchange Rate (Peso to Dollar), and Bitcoin closing prices through the use of a time series approach. The study was conducted in order to confirm the effects of the Bitcoin closing prices and Peso-dollar exchange rate to the PSEi.

1.1 Objectives

The general objectives of the study is to build a time series model that represents the dynamic relationships among the Philippine Stock Exchange, Exchange Rate (Peso to Dollar), and Bitcoin closing prices. Specifically the study has the following objectives:

i. To identify the underlying/latent relationships between Bitcoin and Philippines stock exchange

ii. To identify the underlying/latent relationships between Exchange Rate and Philippine stock exchange

2 Review of Related Literature

2.1 Bitcoin

Bitcoin, as introduced by its creator(s) under the name of Satoshi Nakamoto (2009), is described as a solution to the double-spending problem in using a peer-to-peer, online network transactions using electronic cash. The problem comes from the fact that the payments are sent directly from one party to another without going through a financial institution and this, according to Nakamoto, gives this sort of transactions an inherent weakness of being dependent on a trusted third party for processing. Aside from reliance to a trust-based model, there is also the cost of mediation needed for transactions. Bitcoin solves these problems by using a peer-to-peer distributed timestamp server that will keep track of the chronological order of transactions, securing the necessary proof of all transactions that will be done, effectively removing the need for a third party mediation.

Meanwhile, an article by Berentsen and Schar (2018) describes Bitcoin as a virtual monetary unit, and therefore has no physical representation. It was stated in the article that the motivation behind bitcoin was to develop a cash like payment system that permitted electronic transactions. One of bitcoin's key features is the absence of a centrally managed ledger – there is no central authority with an exclusive right to keep accounts. Meaning, agents does not need to trust central authorities because these centralized systems are vulnerable to hacker attacks, technical failures, and malicious governments that can easily interfere and put funds at risk. In contrast to this, a paper by Klabbers (2017) investigated whether bitcoin as an investment asset that offers diversification benefits, and whether bitcoin has hedge or safe haven properties. Using the mean variance framework to analyze the performance of the bitcoin with the combination of

Monte Carlo Simulation to further address the estimation risk issue which is an important aspect for a volatile asset such as bitcoin, it was concluded that bitcoin is a decentralized digital currency which can be classified more of an investment asset rather than currency, except that it is not a hedge or safe haven.

2.2 PSEi

The Philippine Stock Exchange Composite is meant to represent the general movement of the stock market. It is a fixed basket of 30 common stocks of selected companies meeting certain set of criteria. These criteria are as follows: company's free float level must be at least 12%, among the top 25% in terms of median daily value in 9 out of 12 month period review and among the top 30 qualified companies based on full market capitalization.

A study by Wu, Lu, Jono, & Perez (2012) investigated the interrelationship between Philippine Stock Exchange Index and USD Exchange Rate through time series Analysis in Philippine Market using monthly data from July 1997 to July 2010. Using Cointegration test, the results showed that there is a stable long-term relationship between the two series. Furthermore, Vector Error-Correction Model was used to identify the effect of each variable and the results showed that PSEi's trend movement will increase intensely in the short run, but the movement will tend to become 0 in the long run. Whereas the growth of USD exchange rate will keep dropping for some reason.

2.3 Exchange Rate

In financial terms, exchange rate refers to the value of one currency when it is exchanged for another and also represents the relation between one countries to another (O'Sullivan & Sheffrin, 2003). In this study, we will be talking about the Philippine Peso to US Dollar Exchange Rate. A country's Exchange Rate should be kept track of for the following reasons: it is a determinant of economic health and plays a vital role in level of trade, something critical to most free market economies.

2.4 Bitcoin, Exchange Rate and PSEi relationship

There are news that the cryptocurrency rise are one of the factors that can explain the decrease in stock markets. One of the studies we have found attempted to validate this claim and

was successful in doing so. Constructing a predictive model with cryptocurrencies as predictors, the model they constructed outperformed the conventional time-series models like ARIMA and ARFIMA models (Isah & Raheem, 2018).

We have also found a paper that specifically studied the transmission of shocks between cryptocurrencies using the well-known Bitcoin and traditional asset classes which included foreign exchange and stocks. Kurka (2017), the researcher, utilized and combined several methodologies or concepts recently proposed and developed by previous researchers to assess the connectedness between the asset, and transmission asymmetries. Contrary to previous studies on assets from a single asset class, however, the study found significant positive asymmetry in spillovers between the assets included in the study. Despite most of the results not supporting the notion that Bitcoin is relevant as an instrument to other markets, there is empirical evidence that market situation for Bitcoin can influence that of other assets'. The results also show that there was significant spillovers from Bitcoin to Gold following the price crash on the market for Bitcoin, further supporting Bitcoin's relevance for financial markets by transmitting its shocks to gold. (Kurka, 2017).

Additionally, there is also an analysis done by Anna Loseva (2016) analyzing the influence of the cryptocurrency Bitcoin on Russian economy, particularly on money supply and inflation, using regression models. Using the most suitable model, it has been found that an increase in the number of bitcoins in circulation decreases money supply. More specifically, a 1% increase in the number of bitcoins in circulation decreases the money supply by 0.394%. This is important because several studies (Pích, 2017; Maskay, 2007) has shown that money supply is positively related to the stock market represented by the S&P 500 index, an American stock market index including 500 leading companies of the US and capturing approximately 80% coverage of available market capitalization.

For the relationship of Stock Market and Exchange Rate, a study by Sani and Hassan (2018) examined the linkage between the exchange rates and stock market in Nigeria using annual data from 1985 to 2015. Using the bound test for ARDL, the results indicate that in the long run, the exchange rate has positive and statistically significant influence on the stock market fluctuations in Nigeria. It was stated that this is because of the preposition that economic growth is associated with the increase in performance of all the sectors in the economy with the stock market being one

of them. Further, on the direction of causality, it was found out that exchange rate granger cause stock market without feedback effect.

2.5 Variables involved in the study

All of the data used were daily (weekdays only) from January 1, 2014 to May 26, 2018 in Peso.

i. Bitcoin - Bitcoin closed price (in dollars)

ii. PSEi - Philippine Stock Exchange Composite Index

iii. Exchange Rate (Peso to Dollar, in peso)

The data for Bitcoin and PSEi were taken from investing.com, and ER was taken from the website of Banko Sentral ng Pilipinas (BSP).

## 3 PSEi, Bitcoin closing price and Peso-Dollar exchange Exploratory Data Analysis
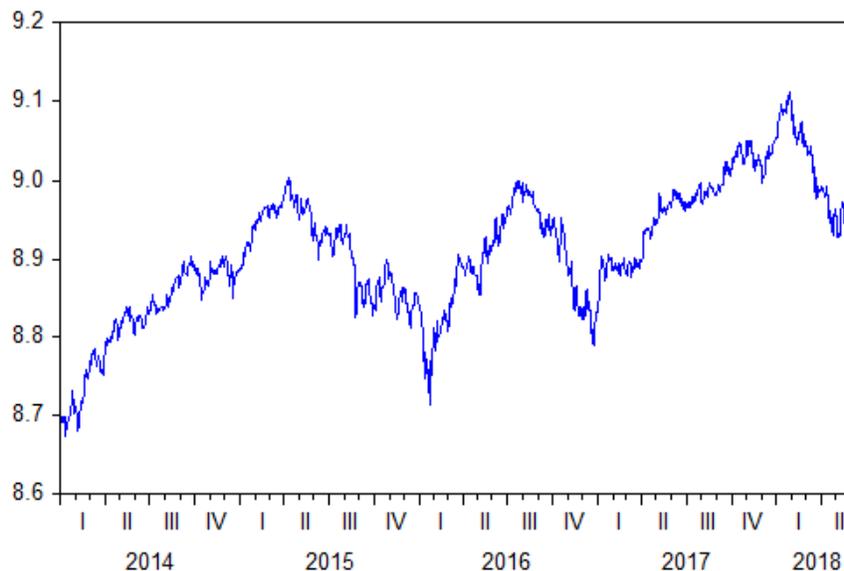
Figure 1. Line Graph PSEi (natural logarithm)

From the figure above, the graph of the PSEi, that it has a seemingly non-stationary movement. There seems to be a general upward trend. It also seems to exhibit a cyclical movement but the cycles vary in length.

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Figure 2. Line Graph of Closing Price of Bitcoin (in Dollar and natural logarithm)

We can see from the figure above, that the bitcoin value had a decreasing trend from 2014 to 2015. From the 3rd quarter of 2015, however, we can see that the bitcoin value steadily went up and this growth in value also picked up from mid-1st quarter of 2017. This growth lead to its maximum value, which is 19114 dollars, Bitcoin's greatest boom before year 2018 where it suffered a decline again.
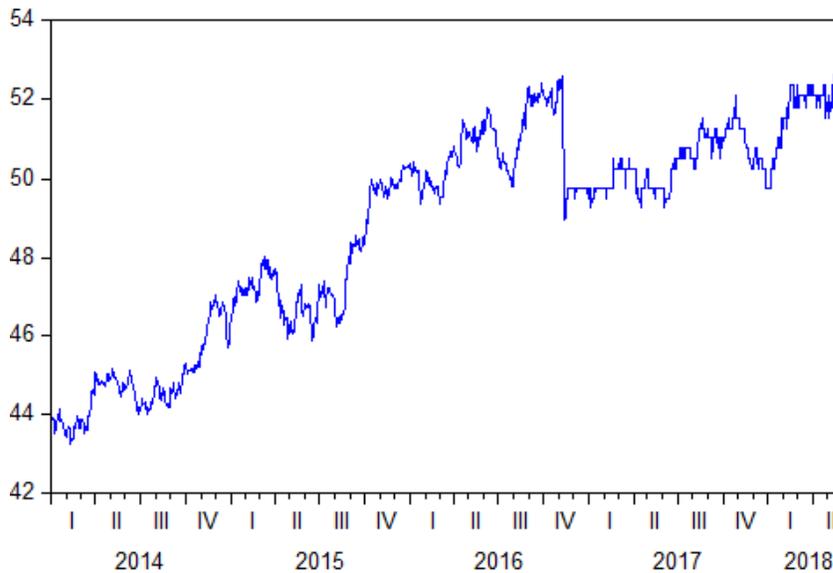
Figure 3. Line Graph of Peso-Dollar Exchange Rate (in Peso and natural logarithm)

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From the figure above, we can see that the Peso-Dollar Exchange Rate has been steadily increasing from 2014 to 2016 before experiencing a sudden drop at the 4th quarter of 2016. This could probably be attributed to the new administration. However, following the drop, it has been increasing since then and has reached top values again on 2018.

To know the optimal method to use in creating the model that will yield the best result, a cointegration test (VAR-based and residual-based) with the series peso-dollar exchange, bitcoin closing prices and Philippine stock exchange index were carried out and the results are in Table 1.1 for the VAR-based.

Table 1.1 Johansen Cointegration Test

Hypothesized number of Cointegrating Equations (Trace Test)	Eigenvalue	Trace Statistic	Critical value	Probability
None	0.011792	19.86515	29.79707	0.432
At most 1	0.005498	6.306833	15.49471	0.6593
At most 2	4.70E-06	0.005371	3.841466	0.9409
Hypothesized number of Cointegrating Equations (Max-eigenvalue test)	Eigenvalue	Max-Eigen Statistic	Critical Value	Probability
None	0.011792	13.55832	21.13162	0.4023
At most 1	0.005498	6.301462	14.2646	0.5748
At most 2	4.70E-06	0.005371	3.841466	0.9409

Remark(s): Trace test indicates no cointegration at the 0.05 level, Max-eigenvalue test indicates no cointegration at the 0.05 level.

The Max-eigenvalue test and Trace test indicates no cointegration at 5% level of significance.

Table 1.2 Engle-Granger Cointegration Test

Test statistic	Value	Probability
Engle-Granger tau-statistic	-2.840906	0.5175
Engle-Granger z-statistic	-14.83900	0.5672

Remark: The series are not cointegrated at 0.05 level of significance.

Based on the Engle-Granger Cointegration test, the series PSEi, Bitcoin closing price and peso-dollar exchange are not cointegrated.

Both of the residual based test, Engle-Granger Cointegration Test and VAR based test, Johansen Cointegration test indicates no presence of cointegration existing among all the three series. Hence, the model that was carried out is Vector Autoregressive (VAR).

4 Vector AutoRegressive (VAR) Model for PSEi

This paper explains the dynamic relationships and patterns of Philippine Stock Exchange (PSE) through the selected determinants which are the PSE closing prices, peso-dollar exchange and Bitcoin closing prices. Through the use of the Vector AutoRegressive model the impact of shocks on PSE were scrutinized.

The Philippine Stock Exchange Index (PSEi) is meant to represent the general movement of the stock market. It is a fixed basket of 30 common stocks of selected companies meeting certain set of criteria. Exchange rate (ER) represents the value of one currency as it was exchanged for another currency and also represents the relations between two countries. The study used the Bitcoin's closing prices. It is a decentralized, non-regulated online monetary cash. All of the data used were converted to Peso and from January 1, 2014 to May 26, 2018. The data for Bitcoin and PSEi were taken from Investing.com, while the data for ER was taken from Banko Sentral ng Pilipinas (BSP).

Table 2. Descriptive Summaries of Bitcoin, PSEi and Exchange Rate

	Bitcoin(in peso and natural logarithm)	Peso-Dollar Exchange	Philippine Stock Exchange Inc (PSEi)
Mean	2100.116	48.71529	7423.980
Median	592.1450	49.75124	7363.885
Maximum	19114.20	52.63158	9058.620
Minimum	178.1000	43.22500	5842.880
Std. Dev.	3474.349	2.657113	614.8233
Skewness	2.407983	-0.512951	0.002952
Kurtosis	8.398295	1.923969	2.780357
Jarque-Bera [Probability]	2503.363 [<0.0000]	105.7269 [0.000002]	2.309297 [<0.0000]

We can see that all throughout the five years, since the first day of 2013 until the 27th of May, the average value of Bitcoin is 2100.116 dollars (1 bitcoin is equal to this). It is also noticeable that the minimum value of the bitcoin is far from the average and the standard deviation (3474.349) is greater than the mean (2100.116), exhibiting how highly dispersed the values are. It is also evident that the Bitcoin values throughout the years is highly skewed to the right, For the Philippine Stock Exchange Index, the average value throughout the five years is 7363.885.

The Jarque-Bera test for each series has a p-value <0.05, hence the null hypothesis of normality of the data was rejected at 5% level of significance. Therefore, all the three series are non-normal.

4.1 Augmented Dickey-Fuller (ADF) Test

Augmented Dickey-Fuller Test was used to test for the presence of unit roots for time series on Philippine Stock Exchange Index (PSEi), Bitcoin, and Exchange Rate (ER) prior to building the VAR model. The results in Table 3 show that all the time series have unit root. The p-value of all the series verified for presence of unit root have p-values surpassing 0.05, hence stationary at 5% level of significance. Thus, the difference of natural logarithm of PSEi, natural logarithm of bitcoin, and ER was used in carrying the VAR model.

Table 3. Results of the Augmented Dickey-Fuller Test (ADF)

Variable	t-Statistics	p-value	Remarks
Philippine Stock Exchange Index (in natural logarithm)	-2.772946	0.2077	Non-stationary; I(1) series (at 5% level of significance)
Bitcoin Closing Price (in natural logarithm)	-1.915016	0.6459	Non-stationary; I(1) series (at 5% level of significance)
Exchange Rate	-2.878385	0.1699	Non-stationary; I(1) series (at 5% level of significance)

4.2 Granger Causality

To determine whether one time series is useful for forecasting another, we need to investigate whether a time series X can help forecast a time series Y -- when time series X *Granger Causes* Y (without feedback). Using the Granger Causality test, the null hypothesis that Bitcoin closing prices does not Granger Causes PSEi is rejected at 1% level of significance. Hence, Bitcoin closing prices Granger Causes PSEi but not the reverse. Aside, the null hypothesis that Peso-Dollar Exchange does not Granger Causes PSEi at 5% level of significance. Therefore, Peso-Dollar Exchange Granger Causes PSEi. The set of all the variables indicate that the two Granger Causes the PSEi.

Table 4. Results of Granger Causality Test for the Dependent variable PSEI

Variable	Chi-sq	df	Prob.
Bitcoin(in natural logarithm)	20.47054	9	0.0152**
Exchange Rate	17.69624	9	0.0389**
All	38.21681	18	0.0036**

** Bitcoin Granger Causes PSEi but not the reversed (at 1% level of significance)

4.3 The VAR Model

In order to capture the dynamics and the multiple interdependencies among these time series, vector autoregressive (VAR) is used. It is regarded as the generalization of the Univariate Autoregressive models. For example if the study has a lag 1 model, then we have,

$$i. PSEit = \beta_{10} - \beta_{11}ER_t - \beta_{13}Bitcoin_t + \gamma_{11}PSEi_{t-1} + \gamma_{12}Bitcoin_{t-1} + \gamma_{13}ER_{t-1} + \varepsilon_{PSEi\ t}$$

$$ii. Bitcoin_t = \beta_{20} - \beta_{21}PSEi_t - \beta_{23}ER_t + \gamma_{21}PSEi_{t-1} + \gamma_{22}Bitcoin_{t-1} + \gamma_{23}ER_{t-1}$$
$$+ \varepsilon_{bitcoin\ t}$$

$$iii. ER_t = \beta_{30} - \beta_{31}PSEi_t - \beta_{32}Bitcoin_t + \gamma_{31}PSEi_{t-1} + \gamma_{32}Bitcoin_{t-1} + \gamma_{13}ER_{t-1} + \varepsilon_{ER\ t}$$

Where PSEi$_t$ is the Philippine stock exchange index, Bitcoin$_t$ is the Bitcoin price in peso and ER$_t$ is the exchange rate all at day t. The $\varepsilon_{PSEI,t}$, $\varepsilon_{bitcoin,t}$, $\varepsilon_{ER,t}$ are white noise disturbance with mean 0 and standard deviations, σ_{PSEi} , $\sigma_{bitcoin}$ σ_{ER} respectively. These equations are called the structural equations of VAR. The parameters β_{12} β_{13} β_{21} β_{23} β_{31} and β_{32} measure the contemporaneous effects while $\gamma_{11}, \gamma_{12}, \gamma_{13}, \gamma_{21}, \gamma_{22}, \gamma_{23}, \gamma_{31}, \gamma_{32}$ and γ_{33} measure the lag 1 effects.

The result of model using the daily time series (weekdays only) on Philippine stock exchange index, bitcoin, and exchange rate are given below. The first, second, fourth, fifth, eighth, ninth, eleventh, twelfth, twentieth lagged equation of the VAR is used where the dependent

variable is Philippine stock exchange index. The paper is interested with the 3rd column (which is tabulated and reported on Table 5 below) of the Eviews VAR model output where the dependent variable is the Philippine stock exchange index.

Table 5. The VAR model (selected parts of whole)

	Philippine Stock Exchange(1st difference, in natural logarithm) – Dependent Variable		
	Bitcoin Closing Prices (1st difference, in natural logarithm)	**Exchange Rate (1st difference)**	**Philippine Stock Exchange (1st difference, in natural logarithm)**
Lag 1	0.001399	0.002414	0.001129
	(0.00584)	(0.00135)	(0.0299)
	[0.23940]	[1.79303]*	[0.03777]
Lag 2	0.007203	0.000967	-0.04301
	(0.00584)	(0.00135)	(0.0299)
	[1.23365]	[0.71718]	[-1.43870]
Lag 4	0.011952	0.000652	-0.02302
	(0.00582)	(0.00135)	(0.03005)
	[2.05435]**	[0.48271]	[-0.76613]
Lag 5	0.006209	0.001757	0.002839
	(0.00583)	(0.00134)	(0.02985)
	[1.06442]	[1.30723]	[0.09508]
Lag 8	-0.01247	0.002838	0.025074
	(0.00582)	(0.00134)	(0.02992)
	[-2.14386]**	[2.11058]**	[0.83795]
Lag 9	-0.01551	-0.00029	-0.02163
	(0.00584)	(-0.00135)	(0.02986)
	[-2.65476]**	[-0.21512]	[-0.72432]
Lag 11	0.004282	-0.00166	-0.02461

	(0.00585)	(0.00135)	(0.03018)
	[0.73184]	[-1.23151]	[-0.81514]
Lag 12	-0.00305	-0.0012	0.035379
	(0.00584)	(0.00136)	(0.03012)
	[-0.52250]	[-0.88223]	[1.17460]
Lag 20	0.008598	-0.00314	0.046937
	(0.0058)	(0.00136)	(0.03012)
	[1.48205]	[-2.30947]**	[1.558135]
Constant	0.000164		
	(0.00027)		
	[0.60380]		

() - Standard Errors

[] – t-statistics

*Significant at 10% level of significance

** Significant at 5% level of significance

We used this sets of lags since this yielded the lowest AIC and SC after trying many different combinations of lags.

The estimated parameters are not that useful in analyzing the dynamic relationships of Bitcoin and Peso-Dollar Exchange on Philippine stock exchange index. Instead, the dynamic relationship of the VAR is derived through the Impulse Response Function (IRF).

4.4 Impulse Response Functions

The Impulse Response Function (IRF) examines how the dependent variable reacts to shocks from each of the predictive variables through the dynamic lag structure of the VAR. The effect of one time shock to one of the innovations on the current and future values of the endogenous variables is traced by the IRF.
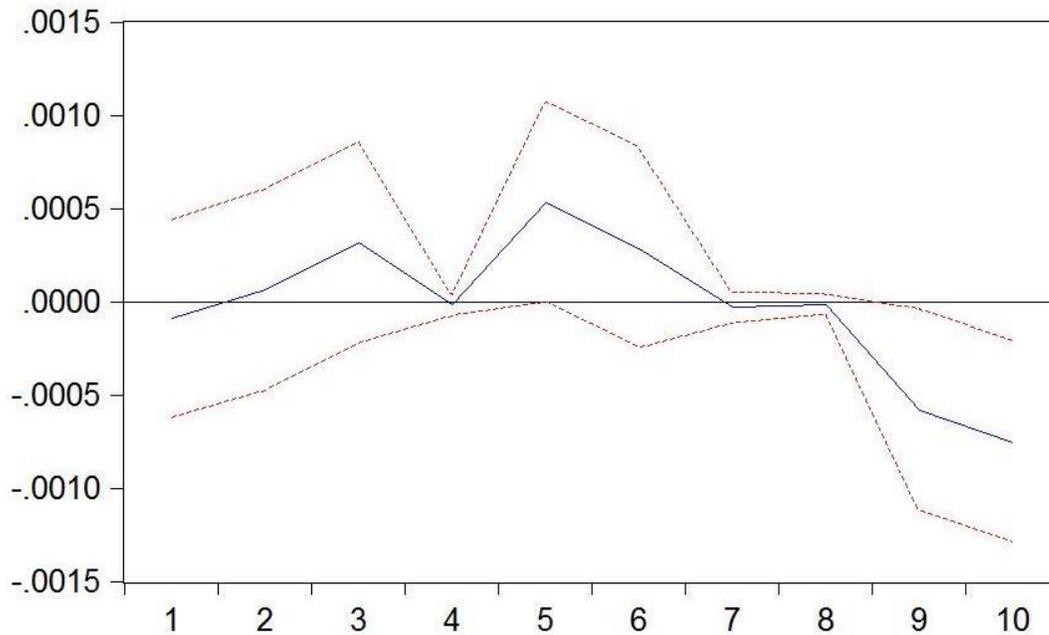
4.5 Impulse Response of PSEi to Bitcoin

Table 6 below exhibits the response of PSEi to Bitcoin. The impulse response function shows that a one-time shock to bitcoin at day t will have a significant effect on PSEi for the 3 periods day (t+4), day (t+8) and day (t+9). The effect of a shock to Bitcoin is significant in increasing PSEi at 10% level of significance for period 5, period 9 and period 10. A one standard deviation increase to Bitcoin at day 5 will increase the PSEi by about 0.000318 standard deviation, at day 9 will increase the PSEi by about -0.00058 and at day 10 will increase the PSEi by about -0.00076. This shows that PSEi is not that sensitive to changes in Bitcoin.

Table 6. Impulse Response Function - Response of PSEI to Bitcoin price to a one standard deviation increase in Bitcoin closing price at Day 1

Period	Bitcoin Closing price (1st difference, natural logarithm)	t-statistics
1	-9.20E-05	-0.346
2	6.36E-05	0.236
3	0.000318	1.18
4	-1.83E-05	-0.647
5	0.000533	**1.99
6	0.000286	1.06
7	-3.30E-05	-0.818
8	-1.57E-05	-0.584
9	-0.00058	**-2.17
10	-0.00076	**-2.80

**Significant at 5% level of significance (two-sided)

Figure 4. Response of PSEI to Bitcoin price

4.6 Impulse Response of PSEi to ER

The IRF result in table below show that a one-time increase in ER at day t will have significant effects on PSEi for the 2 periods, day (t+1) and day (t+8). The effect of a shock to ER is significant in increasing PSEi at 5% level of significance for the 2 days. A one standard deviation increase to ER at day 2 will increase PSEi by about 0.00048 and will increase by about 0.000557 at day 2.

Table 7. Impulse Response Function - Response of PSEi to Exchange Rate

Period	Peso-Dollar Exchange(1st difference)	t-statistics
1	-0.00024	-0.893
2	0.00048	**1.79
3	0.000165	0.615
4	-3.46E-05	-0.969
5	0.000134	0.500
6	0.00031	1.16

7		-3.02E-05	-0.647
8		-1.04E-05	-0.444
9		0.000557	**2.08
10		-0.00013	-0.500

*Significant at 5% level of significance (two-sided)

Cholesky ordering: Bitcoin price, Exchange Rate, PSEi
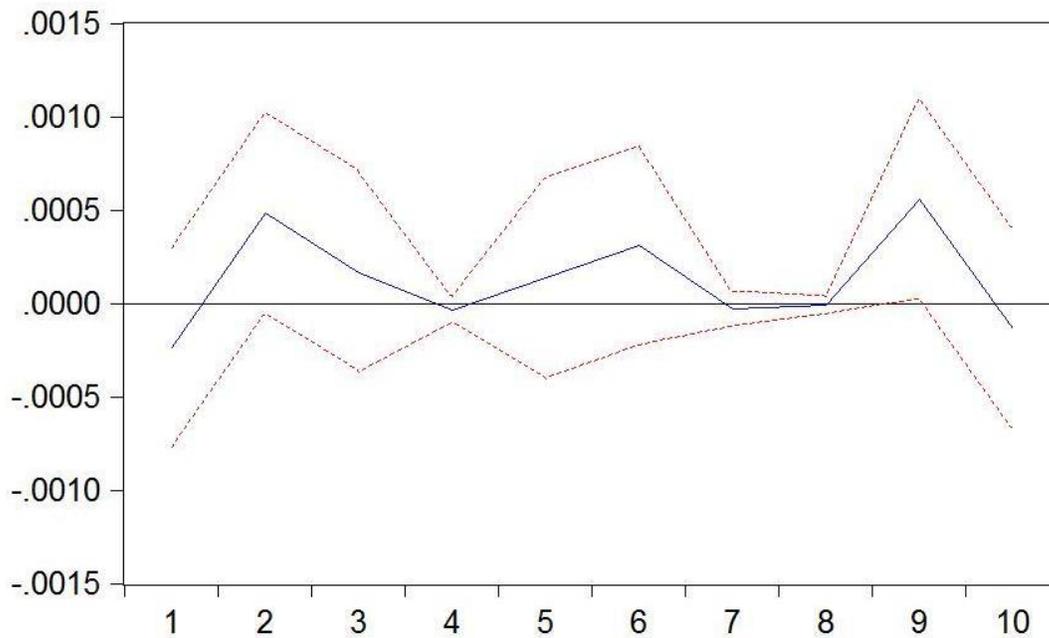
Figure 5. Response of PSEi to Exchange Rate

4.7 Forecast Error Variance Decomposition

The Forecast Error Variance Decomposition trace out the proportion of the movements in the series that are due to their own shocks and shocks to the other variables. It provides information regarding the relative importance of every random innovation in affecting the variables in the VAR model. The Forecast error variance decomposition of PSEi as seen in table 7 below shows how much of the future forecast error variance decomposition of PSEi can be explained by the shocks to PSEI, Bitcoin closing prices and Peso-dollar exchange rate at day. The shock of PSEi (its own shock) at t>=1 explains almost all, 96.54% to 99.10% of the forecast error variance decomposition

of PSEi. But it can be observed that at t>=1, the bitcoin closing price explains at least 0.01% to at most 1.6998% of the forecast error variance decomposition of PSEi. It is important to notice that as time went by, the forecast error variance decomposition that can be explained by the Bitcoin prices to PSEi is growing. It can be observed that at t>=1, the exchange rate can explain at least 0.076% to at most 0.9258% of the forecast error variance decomposition of PSEi. Also, the forecast error variance decomposition of exchange rate is growing.

Table 8. Forecast Error Variance Decomposition of PSEi

Day	S.E.	Bitcoin closing price	Exchange Rate	PSEi
1	0.046028	0.010627	0.070671	99.9187
		(0.146992)	(0.236408)	(0.279)
2	0.04608	0.015653	0.359209	99.62514
		(0.180536)	(0.443495)	(0.490602)
3	0.046101	0.141783	0.391941	99.46628
		(0.315315)	(0.473977)	(0.55519)
4	0.046101	0.142195	0.393418	99.46439
		(0.315416)	(0.475812)	(0.557008)
5	0.046125	0.49401	0.414195	99.0918
		(0.481765)	(0.489302)	(0.666156)
6	0.046141	0.594594	0.532347	98.87306
		(0.525048)	(0.500557)	(0.721466)
7	0.046141	0.595928	0.533461	98.87061
		(0.527709)	(0.50356)	(0.724369)

8	0.046141	0.596229	0.533589	98.87018
		(0.528397)	(0.504019)	(0.725417)
9	0.046249	1.009511	0.910425	98.08006
		(0.662382)	(0.600704)	(0.886253)
10	0.046324	1.699816	0.925821	97.37436
		(0.844421)	(0.602634)	(1.103852)

() - Monte Carlo Standard Errors

4.8 Diagnostics

On table 9.1 the hypothesis that there is no serial correlation were not rejected for all lags at 10% level of significance. Hence, no serial correlation is present. Table 9.2 shows that at 5% level of significance, the hypothesis that the model is not heteroskedastic is rejected. Hence, the VAR model created is heteroskedastic. Table 9.3 shows that the Jarque-Bera test p-value<0.05, and therefore at 5% level of significance, there is non-normality of error terms existing in the VAR model. All of these diagnostics were expected to happen since the series being scrutinize are of high volatility and this is supposed to happen in a financial time series. Hence, a multivariate Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) was created thereafter.

Table 9.1 VAR Residual Serial Correlation LM Tests

Lags	LM-Stat	Probability
1	5.072271	0.828
2	9.30035	0.41
3	7.11513	0.6251
4	7.681204	0.5666
5	4.405382	0.8828
6	11.59434	0.2372

7	6.239151	0.7158
8	7.853976	0.5489
9	14.11071	0.1184
10	7.681034	0.5666

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Table 9.2 Joint Test Results of Heteroskedasticity Test

Chi-square statistic	Degrees of Freedom	p-value	Remark
506.6679	324	< 0.0000	Heteroskedastic

Table 9.3 VAR Residual Normality Tests

Component	Jarque-Bera Statistic	Degrees of Freedom	p-value	Remark
Joint	382521.1	2	<0.0000	Non-normal

4.9 M GARCH Model - Diagonal VECH

Due to the diagnostics not meeting the required assumptions of the model, a multivariate Diagonal VECH- Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) were created.

Below is the model with Substituted Coefficients:

i. *GARCH1* = 2.91102388421e-05 + 0.169727854683*RESID1 (-1) ^2 - 0.0396110896346*RESID1 (-1) ^2*(RESID1 (-1) <0) + 0.845515365678*GARCH1 (-1)

ii. *GARCH2* = 0.00028685962879 + 0.0015456926671*RESID2 (-1) ^2 - 0.00360432182999*RESID2 (-1) ^2*(RESID2 (-1) <0) + 0.992224114919*GARCH2 (-1)

iii. GARCH3 = 1.99880069584e-06 + 0.0118672019177*RESID3 (-1) ^2 + 0.0673624972181*RESID3 (-1) ^2*(RESID3 (-1) <0) + 0.938423064058*GARCH3 (-1)

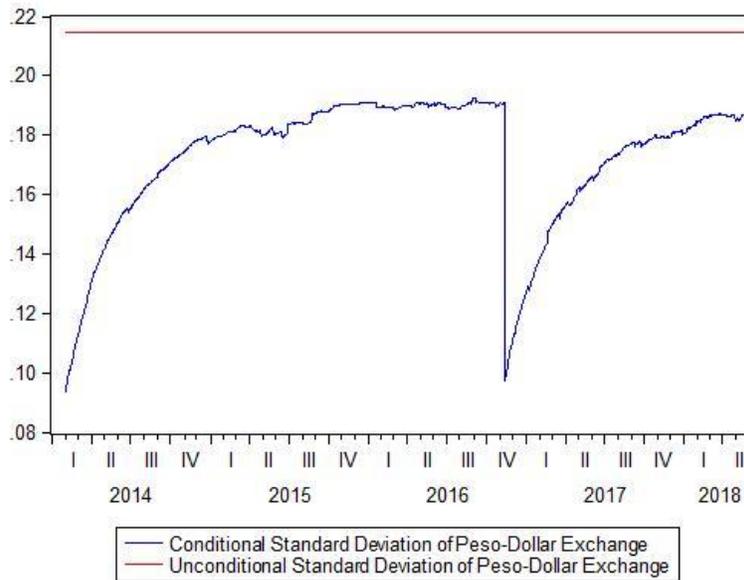Conditional Correlations of Bitcoin closing prices, Peso-Dollar Exchange and PSEi
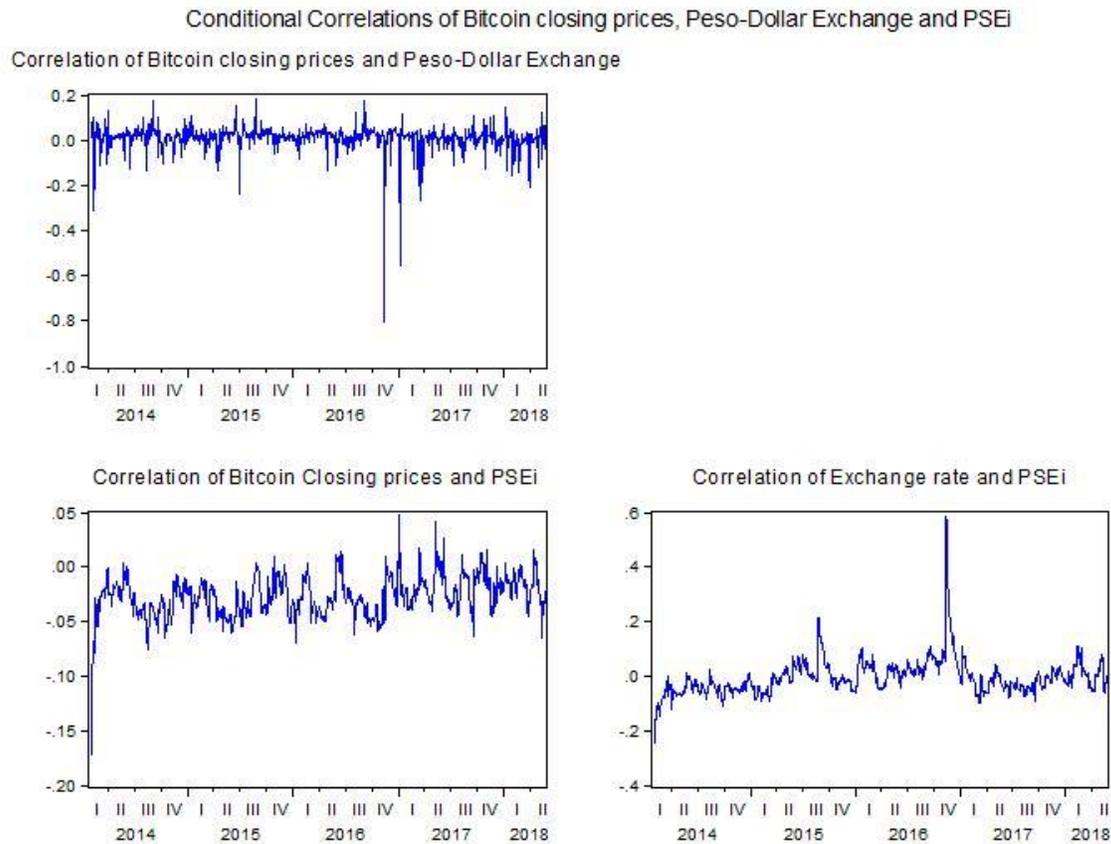
Figure 6. Cross Conditional Correlations of Bitcoin closing prices, Peso-Dollar Exchange and PSEi
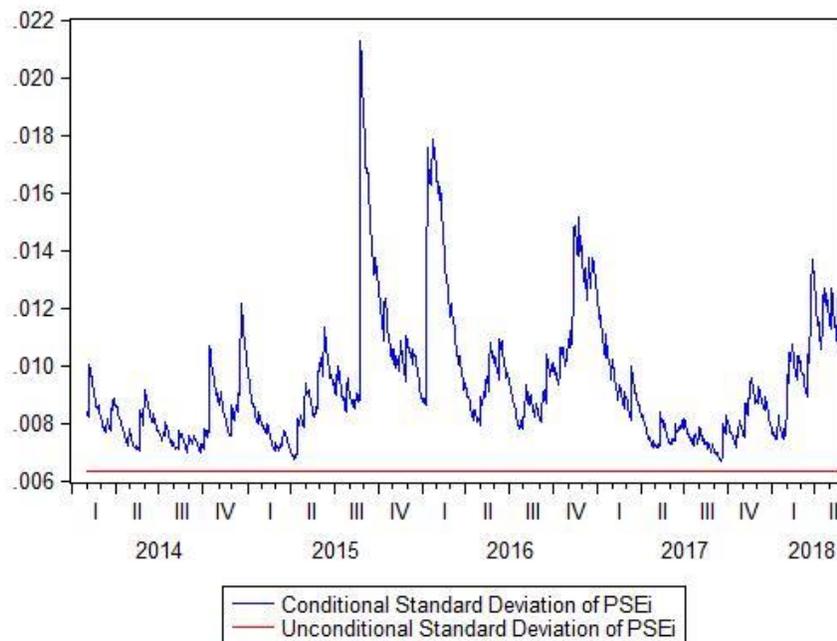
We can see on the figure above the conditional correlations of bitcoin closing prices, Peso-Dollar Exchange and PSEi. As we can see that the conditional correlation of the bitcoin closing prices and peso-dollar exchange are spiking but close to zero with some spill-overs especially at 2016 fourth quarter going to 2017 first quarter. Referring to the conditional correlation of the Bitcoin closing prices and PSEi, it can be seen that their correlation are close to -0.6 to -0.5 with spikes as well. Lastly, the conditional correlation of Exchange rate and PSEi is close to -2 to -1 with bigger spillovers among the other graphs.
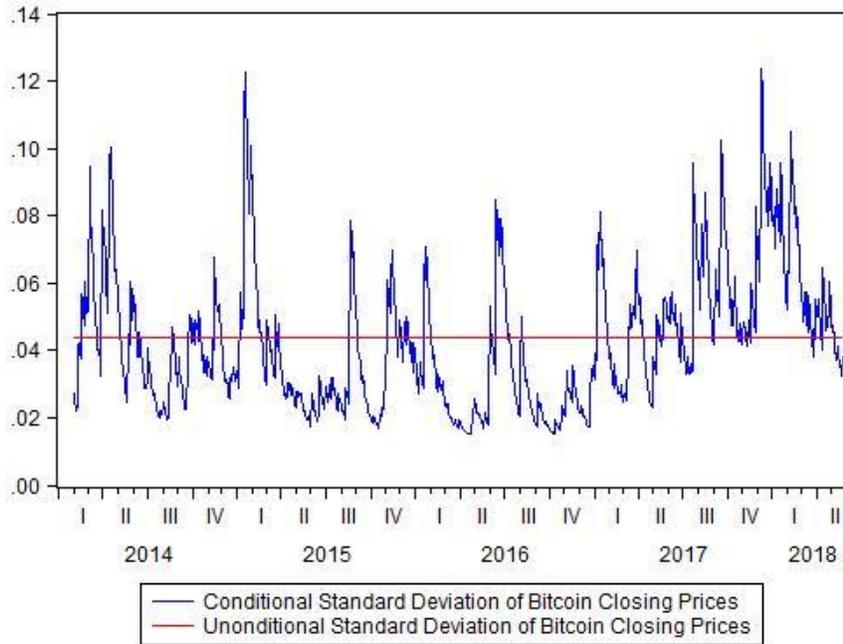
Figure 7. Conditional and unconditional standard deviation (equal to 0.01750597) of Bitcoin closing prices.

Figure 8. Conditional and unconditional standard deviation (equal to 0.160824047) of Peso-Dollar Exchange

Figure 9. Conditional and unconditional standard deviation (equal to 0.005185567) of Bitcoin closing prices.

We can see on figures 9 that the risks of PSEi is above the unconditional standard deviation, hence, the spillover of the risks is large. On the other hand the conditional standard deviation of bitcoin closing prices is on the middle as referred on figure 7, hence the conditional volatility is close or approaches the real volatility of bitcoin closing prices with just some fluctuations. The Peso-Dollar Exchange on the other hand has its conditional standard deviation below the unconditional standard deviation, hence the risks are negative.

Conclusion

This study examines the dynamic relationship of Philippine Stock Exchange Index on Bitcoin closed prices and the Peso-Dollar exchange. The results of the vector autoregressive (VAR) model show that a one-time increase in Bitcoin closed prices can lead to increases in Philippine stock exchange index for day 5, decrease in Philippine stock exchange index for 2 succeeding days, day 9 and day 10; its shock does not linger long to the Philippine Stock Exchange

due to its high volatility and inconsistency. While a one-time increase in Peso to Dollar exchange will lead to an increase in Philippine stock exchange that will last for 2 separate days only.

Also, the future forecast error variance decomposition of PSEi that can be explained by both bitcoin Bitcoin closing prices and Peso-Dollar Exchange are relatively small.

Looking at the IRF of the bitcoin closing prices, on the start of the periods, this found out that the bitcoin has a relatively small positive effect to stock market, this is probably due to it being new, decentralized, and unregulated. But as the time went by, there was a small negative effect that was caused by the sudden popularity and hype of the bitcoin to a lot of people, the companies and the investors joined the bandwagon as it being more of an investment than a currency. Thus, this is similar to the "Theory of Mind" that people have the same mentality of investing in bitcoin because of its value is increasing and that many people are getting into it (De Martino, et al., 2013). The results provided by the variance decomposition pertains to bitcoin being new to the industry and the world, starting just in 2009 and worth of less than a hundred dollar last 2011 but made it's boom at the year 2017, with price amounting up to $17,000 (Shane, 2017). Since the gained popularity of the bitcoin, people's interest have become high, especially for young people. According to the recent survey of the Blockchain last January 2018, it was found out that 30% of the Millennials aging 18-34 years of age would rather invest their $1000 in Bitcoin rather than the bonds and stocks of the government. It was added to the report of Shane (2017) that the managing director of Octagon Strategy, a Hong Kong-based cryptocurrency exchange Dave Chapman (2017), said that one of the factors that driving the bitcoin prices to soar up high is the "Fear of Missing Out" to the hype of investing on the bitcoin.

Furthermore, the researchers only found few published studies in support of the relationship of Peso-Dollar Exchange and stock market as most deemed the two to be independent of each other. However, this study has proven that there is indeed an underlying relationship between the Exchange Rate and the Philippine Stock Exchange Rate. Additionally, it has been found that a significant amount of variability of the Stock Market can be explained by Bitcoin and Exchange Rate. The study was in line with the paper published by Sani and Hassan that (2018) examined the linkage between the exchange rates and stock market in Nigeria with results indicating that in the long run, the exchange rate has positive and statistically significant influence on the stock market fluctuations in Nigeria which can also be reflected on the future error variance decomposition of Peso-Dollar exchange to PSEi.

Furthermore, the three series were subjected through GARCH model and found out that the spillover of PSEi is large and the Peso-Dollar Exchange is below its unconditional risk and the bitcoin risk is just coinciding the line of the unconditional standard deviation hence, a possible stability with some spillovers.

For future studies, another model should be carried out (BEKK model) and done in order to further assess the effects and volatility of the variables involved in the study.

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