THE DYNAMIC LINKAGE BETWEEN BITCOIN AND BGCI CRYPTOCURRENCIES: A WAVELET APPROACH

BY

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ABSTRACT

This dissertation is written for the purpose of understanding the individual and paired movements of major cryptocurrencies by analysing their historical data in log-returns, recorded from their launch date of the index to the latest available information (May 2018 to December 2019), through the use of wavelet analysis. Specifically, we conduct the analysis using two wavelet methodologies, known as the Continuous Wavelet Transform (CWT) and the Maximal Overlap Discrete Wavelet Transform (MODWT). We analyse the constituents of the Bloomberg Galaxy Crypto Index (BGCI), which consists of Bitcoin, Bitcoin Cash, EOS, Ethereum, Litecoin and Ripple. Firstly, we find that among the six major cryptocurrencies, Ripple has the most potential to be a true alternative currency to, but definitely not replace, traditional fiat currencies in the future. Secondly, in regard to the prime cryptocurrency of Bitcoin and its impacts, there is significant evidence to suggest that Bitcoin's returns lead four of the five cryptocurrencies' returns in the long-run, with the exception of Litecoin where vice versa occurs instead, indicating that Litecoin is possibly becoming more market-efficient due to its 1) independence of Bitcoin, and 2) price reaction ahead of Bitcoin. However, in the short- to medium-run spectrums, we can see that Bitcoin provides different shocks to its counterparts, such that either cryptocurrency in the Bitcoin-pair could lead each other in an in-phase direction (anti-phase co-movements are extremely rare in all spectrums). Thirdly, with respect to portfolio diversification by using the prime cryptocurrency, pairing Bitcoin with Ripple shows the most potential benefits in a two-asset portfolio construction followed by a pairing with Litecoin, as both pairs project mild positive correlations and they are expected to decline in the long-term – suggesting that using merely cryptocurrencies in the portfolio (crypto-portfolio) can reduce portfolio risk. However, with respect to hedging, we find no evidence to suggest that using Bitcoin and these cryptocurrencies provide any offsetting benefits due to their in-phasing co-movements with Bitcoin in general, as negative correlations do not exist at all scales.

مُلخَّص البحث

يهدف هذا البحث إلى فهم الحركات الفردية والزوجية للعملات المشفرة الرئيسة من خلال تحليل بياناتها التاريخية في عمليات تسجيل الدخول من تاريخ إطلاق المؤشر إلى أحدث المعلومات المتاحة (مايو 2018 – ديسمبر 2019)، من خلال استخدام تحليل المويجات، ويجري التحليل تحديدًا باستخدام منهجين من المويجات يُعرفان بتحويل المويجات المستمر CWT، وتحويل المويجات المنفصل المتقاطع الأقصى MODWT، مع تحليل مكونات مؤشر بلومبرج غالاكسي للتشفير BGCI الذي يتكون من: Bitcoin، Bitcoin Cash، EOS، Ethereum، Litecoin، Ripple، وبعامة؛ نجد أنه من بين العملات الرئيسة الست المشهورة؛ تمتلك Ripple الإمكانية الأكبر لتكون عملة بديلة حقيقية، ولكنها بالتأكيد لا تحل محل العملات الورقية التقليدية في المستقبل، وفيما يتعلق بالعملات الرئيسة المشفرة لعملة Bitcoin وتأثيراتها؛ هناك أدلة مهمة تشير إلى أن عائداتها تتصدر أربعة من عائدات العملة المشفرة الخمسة على المدى الطويل، باستثناء Litecoin إذ يحدث العكس، فربما تصبح Litecoin أكثر كفاءة في السوق؛ بسبب استقلالها عن Bitcoin، وتأثير سعر الأخيرة، ولكن؛ في المدى القصير إلى المدى المتوسط؛ يمكننا أن نرى أن Bitcoin توفر صدمات مختلفة لنظيراتها، فقد تؤدي العملة المشفرة في الزوج Bitcoin إلى قيادة بعضها بعضًا في اتجاه مرحلة "الحركات المشتركة المضادة للطور النادرة للغاية في جميع الأطياف"، وفيما يتعلق بتنويع محفظة الأوراق المالية باستخدام العملة المشفرة الأولية؛ يعرض اقتران Bitcoin وRipple أكثر الفوائد المحتملة في بناء محفظة ثنائية الأصول متبوعًا بالاقتران مع Litecoin؛ إذ يتوقع أن بين الزوجين علاقات إيجابية معتدلة، وأنه في المدى الطويل؛ يمكن لاستخدام العملات المشفرة فقط في محفظة التشفير أن تحدَّ من مخاطر المحفظة، وفيما يتعلق بالتحوط؛ لا دليل يشير إلى أن استخدام Bitcoin وعملات التشفير هذه؛ يوفر أي فوائد مقاصة بسبب تحركاتها المشتركة على مراحل مع Bitcoin بعامة، إذ لا علاقات سلبية على جميع المستويات.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Finance).

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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I dedicate this thesis to my beloved family.

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First and foremost, it has been my great pleasure to contribute this dissertation to the field of finance, and as well as the field of academics. I wish to dedicate this work to my beloved parents, family, current and past educators for their unconditional support towards my ultimate goal of becoming an academician one day – thank you.

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Last but not least, I would like to express my utmost gratitude and appreciation with a special thanks to Professor Azhar Bin Mohamad for his continuous support and encouragement as a supervisor, constant determination as a leader, and as a true friend for believing in me.

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroscedasticity
ARDL	Autoregressive Distributed Lag
ARMA	Autoregressive Moving Average
ARFIMA	Autoregressive Fractionally Integrated Moving Average
BGCI	Bloomberg Galaxy Crypto Index
BPS/bps	Basis Points
BTC	Bitcoins (Unit Form)
CBCC	Central Bank Cryptocurrencies
CI	Confidence Interval
COI	Cone of Influence
CWPS	Continuous Wavelet Power Spectrum
CWT	Continuous Wavelet Transform
DAO	Decentralised Autonomous Organisation
DWT	Discrete Wavelet Transform
ECM	Error Correction Model
EGARCH	Exponential Generalised Autoregressive Conditional Heteroscedasticity
EMH	Efficient Market Hypothesis
EPU	Economic Policy Uncertainty
ES	Expected Shortfall
FBI	Federal Bureau of Investigation
FIGARCH	Fractionally Integrated Autoregressive Conditional Heteroscedasticity
FTSE	Financial Times Stock Exchange
GARCH	Generalised Autoregressive Conditional Heteroscedasticity
GPR	Geopolitical Risk Index
GSADF	Generalised Supremum Augmented Dickey-Fuller
IGARCH	Integrated Generalised Autoregressive Conditional Heteroscedasticity
IPO	Initial Public Offering
KS	Kolmogorov-Smirnov
Ln/ln	Natural Logarithm
M&A	Mergers & Acquisitions
MA	Moving Average
MODWT	Maximal Overlap Discrete Wavelet Transform
MGARCH-DCC	Multivariate Generalised Autoregressive Conditional Heteroscedasticity – Dynamic Conditional Correlation
MRA	Multi-Resolution Analysis
NYSDFS	New York State Department of Financial Services
OVX	Crude Oil Volatility Index
P/E	Price-Earnings Ratio
PIT	Probability-Integral Transform

POW	Proof-of-Work
R/S	Rescaled Range
TPI	Trade Policy Uncertainty Index
US	United States
USD	United States Dollar
VaR	Value-at-Risk
VAR	Vector Autoregressive
VEC/VECM	Vector Error Correction Model
VIX	Volatility Uncertainty Index
WCOR	Wavelet Correlation
WCCOR	Wavelet Cross-Correlation
WFT	Wavelet Fourier Transform
WMC	Wavelet Multiple Correlation
WMCC	Wavelet Multiple Cross-Correlation
WTC	Wavelet Coherence
XBT	Bitcoin
XBN	Bitcoin Cash
XEO	EOS
XET	Ethereum
XRP	Ripple
XLC	Litecoin
XWT	Cross-Wavelet Power

e.g.	*(exempli gratia)*: for example
et al.	*(et alia)*: and others
etc.	*(et cetera)*: and so forth

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND INFORMATION

The period of the late 2000's witnessed several financial, cunning ploys due to the greed and heavy unruliness of some. In retrospect, examples include the rise of subprime mortgages being treated as worthy securities, the subsequent fall of the Lehman Brothers, followed by the financial contagion spillover across world financial markets due to giant corporations struck in major economies, and so on. The Great Recession had caused a stir, not just among investors attempting to profit in several asset classes, but also among many regular individuals who had been adversely affected by the fall of their own currency. The value of one's means of exchange became weaker yet simultaneously the unemployment line became stronger, and this incident became more worrisome for the average household, especially for the newer generation of youth being impacted in the long-term by these recessional effects (Bell & Blanchflower, 2011).

Coincidentally, a new 'tool' arose in the beginning of 2009 shortly after the plummeting of the world's economy, yet no one is certain of 'who' or 'what set of individuals' revolutionised financial markets with its introduction. In fact, until now, no one could definitively claim its true purpose of existence, such as whether it is a medium of exchange, a financial asset class of its own, or comprising both. Regardless, perspectives of many became simply mere speculations of which led to several major debates of this innovative tool's purpose. Bitcoin, during its initial release and premature stages, was indeed viewed with scepticism regarding its abrupt

arrival after the crises. Eventually passing its infancy, Bitcoin became the 'tool' for many – whether it is used by an investor who deems it as tool for portfolio diversification (Bouri et al., 2016), a citizen who simply buys goods using it as a medium of exchange, or even someone who is in need of a tax break by using Bitcoin's platform as an off-shore account, thus reporting false income (Marian, 2013).

Arguably the first cryptographic currency (also shortly known as 'cryptocurrency') with its own virtual payment system, Bitcoin eventually became whatever the affiliated users desired it to be, and this marvel led to the inventions of many other alternatives of the same asset class attempting to replicate what Bitcoin has achieved.

1.2 MOTIVATION OF THE STUDY

This thesis derives inspiration from, as aforementioned, the constant unending discourse regarding cryptocurrencies and their true purposes as a new asset class. From an investor's perspective, cryptocurrencies are simply financial tools that allow portfolio diversification and hedging with/against other asset classes, alongside a market for profiting off bear- and bull-run periods through buying and selling. From a non-investor's perspective (or simply a common user's perspective), cryptocurrencies can potentially be an alternative means of exchange (also known as alternative currencies or 'altcurrencies' for short) that could potentially overthrow today's current fiat money system controlled by centralised authorities. However, from an academician's perspective, cryptocurrencies could follow both perspectives of the investor and the common user regarding its true nature – assessing their viability as an asset class through this dual-lens view highlights the significance of this study.

The traditional argument of the largest powerhouse cryptocurrency (Bitcoin) claims that since it is the most volatile cryptocurrency in price, therefore it renders zero possibility of becoming a future alternative currency. However, this study assumes no bias by assessing Bitcoin with both aforementioned lenses from the latest available sample. In addition to Bitcoin, several other major cryptocurrencies will be analysed in this dissertation in order to rectify the issue of whether cryptocurrencies in general, have the capability to overcome these stereotypes of extreme volatility and not merely Bitcoin. Consequently, since Bitcoin is generally known to be the market leader of most cryptocurrencies, then it is only logical to then view these assets in terms of their dependence with one another – such that, if their efficiency is low and predictable, which asset(s) do they follow amongst the sample? In contrast, if there is a sign of randomness and unpredictability, would this signify a possibility of the cryptocurrency becoming more efficient in its market? Finally, the analysis is not complete until we have acknowledged these altcurrencies' potential to be risk-diversified/hedged, not with other asset classes, but within its own category – similar to that seen with strategising using solely traditional fiat currencies in international finance. Therefore, this thesis strives to identify and address the true purposes of major cryptocurrencies by purely observing them through an unbiased analysis of their individual and co-movements, such that inferences of their nature can be made with respect to their future.

1.3 PROBLEM STATEMENT

There has been extensive research towards the prime cryptocurrency, Bitcoin, and its concern by several governing institutions from finance, computer science and law

sectors. The significant problem arises as to whether Bitcoin and cryptocurrencies alike are capable of becoming a true asset class of its own, and these factors include whether they can be used as a medium of exchange, as well as whether they can be used as a tool for diversifying/hedging risk. In addition, it is also an imperative issue if there is enough correlative evidence to suggest that Bitcoin impacts all of these cryptocurrencies, which would render their chances low of becoming alternative mediums of exchange for the general public due to being influenced by the prime cryptocurrency. Moreover, it is informative to know at which exact horizon(s) these altcurrencies are being impacted for investors and not merely for regular citizens, assuming that they are indeed influenced by Bitcoin. With traditional econometric methods however, we are simply limited to two-scale dimensions of an asset's movement, which are the short and long runs (we are not able to achieve any informative spectrum in between these two terms' respective lengths). Hence, these issues can be identified and solved more clearly due to a relatively new method called the Wavelet Analysis.

In spite of the existing vast studies, there has been minor coverage of research papers using wavelet analysis regarding other major cryptocurrencies with respect to their overall performance as an alternative to traditional fiat currencies, concerning users who wish to use these assets as a means of exchange – our findings would assist the general public in choosing whether or not to adopt cryptocurrencies in the future, by examining their volatility dimensions. In addition, there has been little discourse using wavelet methodologies regarding Bitcoin's potential impact towards other major cryptocurrencies, or the impact in vice versa direction, viewed in several scales or from different investment horizons. Furthermore, these investment horizons calls for a potential testing of whether it is viable for investors to use these major

cryptocurrencies as a strategy for portfolio diversification or a hedging tool – our findings would assist the concerned investors in determining the worthiness of using crypto-portfolios for their investment, by examining their correlative dimensions.

1.4 RESEARCH OBJECTIVES

Our objectives regarding the performance of major cryptocurrencies in this research are threefold. Firstly, we intend to measure the volatility of the returns of six major cryptocurrencies, currently encapsulating the Bloomberg Galaxy Crypto Index (BGCI), assessing their nature as potential future alternative currencies – these altcurrencies include Bitcoin, Bitcoin Cash, EOS, Ethereum, Litecoin and Ripple. We intend to achieve this first objective by using the Continuous Wavelet Power Spectrum (CWPS) and the Multi-Resolution Analysis (MRA), derived from the Continuous Wavelet Transform (CWT) and the Maximal Overlap Discrete Wavelet Transform (MODWT) respectively. Secondly, we intend to examine if there exists a long-run impact of Bitcoin's returns towards all five cryptocurrencies' returns, and if so, explain the magnitude in all possible investment horizons – we attempt to achieve this second objective by using the Wavelet Coherence (WTC) and the Wavelet Cross-Correlation (WCCOR) models, also derived from the CWT and MODWT as aforementioned. Thirdly, as observable with traditional fiat currencies for investment purposes, we observe if there is a possibility of using these new assets, specifically paired to Bitcoin, as a form of a two-asset portfolio with the intention to diversify and/or hedge risk – the purpose of using Bitcoin as a fixed choice, such that it is the largest cryptocurrency based on today's market capitalisation, it is thus sensible to put this cryptocurrency as a mandatory option due to its high value and popularity. We

intend to achieve this third objective by using the Wavelet Correlation (WCOR) model. For clarification, the research objectives are listed below:

i. To measure the volatility dimensions of the six major cryptocurrencies currently encapsulating the Bloomberg Galaxy Crypto Index (BGCI), in order to examine a potential future of using these virtual currencies as a medium of exchange.

ii. To examine if there exists a long-run impact of Bitcoin's returns towards all other five cryptocurrencies' returns, and if so, explain their dependent magnitudes in all possible investment horizons.

iii. To observe the possible benefits of using these new assets, specifically paired to Bitcoin, as a form of a two-asset portfolio with the intention to diversify and/or hedge risk.

1.5 RESEARCH QUESTIONS

The dissertation is expected to answer the following research questions:

i. Examining each of the six cryptocurrencies individually with respect to their volatility dimensions:

    a. What are the measured volatilities of the log-returns of the BGCI cryptocurrencies from all available horizons?

b. Based on the volatility of their returns, among the six cryptocurrencies, which one has the most potential to becoming a true alternative currency that closely replicates, but not replace, traditional fiat currencies?

ii. Investigating their dependence on the prime cryptocurrency:

a. Does a long-run relationship exist to highly suggest that Bitcoin impacts all five cryptocurrencies with respect to their returns, indicating that Bitcoin is ultimately the yardstick of price valuation for other cryptocurrencies?

b. Following the long-term direction answered in (a.), how is the impact similar/dissimilar in the lower horizons?

iii. Assessing their capabilities as an investing asset class within its own category:

a. Similar to using traditional fiat currencies as a tool for mitigating risk, what are the benefits for investors to use these cryptocurrencies to diversify portfolio risk, given a two-asset portfolio with Bitcoin?

b. Following the aforementioned two-asset portfolio, could these virtual currencies be used as a hedging instrument?

Hence, we hypothesise that these major cryptocurrencies are too volatile in nature to be remotely considered as an alternative to traditional fiat currencies. In addition, their presences of value are highly dependent on Bitcoin as a yardstick for valuation of other cryptocurrencies. As such, because of their high dependence with the prime cryptocurrency, these altcurrencies are not capable of being used in a purely cryptocurrency-based portfolio for diversification, let alone as a hedging instrument amongst each other.

1.6 CONTRIBUTION OF THE STUDY

Alongside from contributing to a newly form analysis of cryptocurrencies with respect to the latest sample, two novel contributions are claimed in this thesis:

i. Firstly, to the best of our knowledge, this is the first investigation and assessment conducted of cryptocurrencies (and their relationships with Bitcoin) from the Bloomberg Galaxy Crypto Index (BGCI) with respect to their historical data, officially launched recently in May 2018 – hence, the chosen beginning period of the analysis. As of 31st December 2019, of which is the ending period of the sample size implemented for this research, there are six cryptocurrencies listed in this index – Bitcoin, Bitcoin Cash, EOS, Ethereum, Litecoin, and Ripple. Similar wavelet studies testing nearly the same chosen variables as this study include studies on Bitcoin and Ethereum (Sifat et al., 2019), assessing Bitcoin, Ethereum, Litecoin and Ripple (Kumar & Anandarao, 2019), and examining Bitcoin, EOS, Ethereum, Litecoin and Ripple (Pavković et al., 2019). However, these three papers omit some of the variables that we