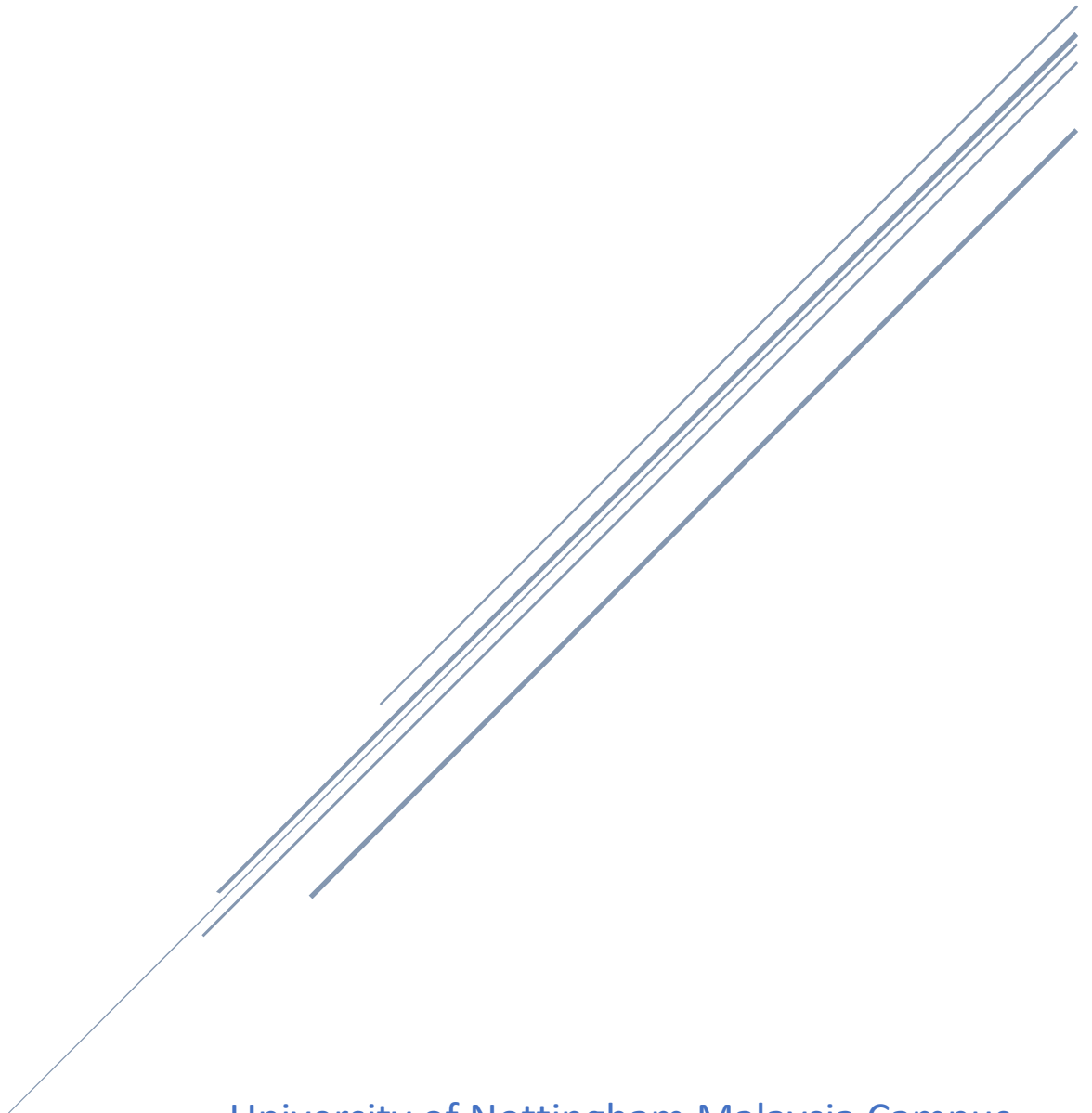# CONSTRUCTING THE BITCOIN MARKET POTENTIAL INDEX:

A principal component analysis approach

University of Nottingham Malaysia Campus
Bachelor of Science in Economics

Constructing the Bitcoin Market Potential index: A Principal Component Analysis Approach

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Abstract:

In this paper Bitcoin Market Potential Index (BMPI) is defined as the total potential utility gained in a country by adopting bitcoin in all means. This index reports usefulness of bitcoin across 178 countries. The data includes eight dimensions and nineteen sub variables. The BMPI is computed using two different weighting schemes, namely the Equal Weighted(EW) and Principal Component Analysis(PCA). The result of both indices is then compared with the Hileman's BMPI. There exists a statistically significant and positive correlation between BMPI under Principal Component Analysis and GDP per capita in logarithmic scale at 5% significance level which null hypothesis cannot be rejected.

Acknowledgments

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1 Introduction and Background

1.1 The Birth of Bitcoin and its Mechanism Design

"The one thing that's missing but that will soon be developed is a reliable e-cash, a method whereby on the internet you can transfer funds from A to B without A knowing B or B knowing A. The way in which I can take a twenty-dollar bill and hand it over to you and there is no record of where it came from and you may get that without knowing who I am." - Milton Friedman, interviewed in 1999.

Although the latter part of this quote was not so accurate to account for the pseudonomity[1] nature of Bitcoin, the late Nobel Laureate in Economics Milton Freidman was close enough to predict the birth of cryptocurrency such as Bitcoin.

In the wake of global recession in 2008 primarily caused by financial deregulation and the greediness of banking industry, Satoshi Nakamoto, whose identity is still unknown, had published the white paper for Bitcoin titled "Bitcoin: A Peer-to-Peer Electronic Cash System". Although this paper is merely nine pages long, it has garnered a lot of attention from media and public as it provides a solid solution to the infamous double spending problem. Unlike other digital currencies existed before, Bitcoin represents itself as the first cryptocurrency that is able to overcome counterfeiting issue by using cryptographic proof without the involvement of third party.

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[1] Bitcoin is not entirely anonymous and untraceable in the sense that it is possible to link one identity with his public key as all Bitcoin transactions are publicly logged.

Despite having a fancy name of Bitcoin, it is not an entirely novel technology invented by Satoshi Nakamoto. In fact, the core idea in Bitcoin is a combination of several technologies existed in the past. However, Bitcoin is the first to combine them altogether and comes out with this unique architecture design. For example, the cryptographic hash function, which is one of the integral parts constituting Bitcoin, was being invented in the 1990s. This Proof of Work (PoW) system and other existing concepts- such as merkle trees, Peer-to-peer network and cryptographic signatures has enabled Satoshi to invent the Blockchain, which is basically the digital distributed ledger based on trustless consensus mechanism.

The main idea of Prove of work (PoW) system is that, in order to be allowed to add a block to the blockchain, the creator of the block has to put in some effort for it. The proof needs to be easy to be proved yet hard to be generated to prevent hacking by brute force. In the case of Bitcoin, the miner gets rewarded with bitcoins for the computational power he puts in to solve cryptographic problem. By solving the cryptographic problem, miners build and maintain the public ledger also known as blockchain containing a record of every bitcoin transaction since the primordial block #0 mined by Satoshi himself.

<u>1.2 Background</u>

In lights of the skyrocketing price of Bitcoin and massive potential of blockchain applications in changing faces of financial industries, cryptocurrency has been reported widely among the mass media for public interest. The perspective of governments also has changed over time, from being disinterested to planning to regulate bitcoin as part of financial world. However, as most countries are still considering ways to impose guidelines for cryptocurrencies, some countries have taken solid actions against bitcoin. For example, Japanese legislature has passed a law recognizing Bitcoin as a form of legal tender. On the other end of the spectrum, we have countries like Bangladesh and Iceland which outright banned Bitcoin as an illegal form of payment. Nonetheless, these news about government regulations seem to have minimal effect to Bitcoin price index, as the bullish market keeps pushing price to a new high.

From the viewpoint of citizens, as some think that the creation of Bitcoin is a an irrational exuberance, people with high hopes on this growing digital currency think that it can be a catalyst for new economy. Indeed, Bitcoin's design as a decentralized peer-to-peer currency provides an innovative way of payment without the involvement of intermediary party. Unlike the traditional payment existed, Bitcoin has the potential to provide a more secured and private payment to others without the acknowledgments of third party. In essence, it can be simplified as a mean of money disintermediation and decentralization. Furthermore, the transaction fee can be significantly smaller and the transaction processing time can be faster with the technological breakthrough of lightning network and SegWit scaling. This monumental achievement has opened up a whole new world for financial banking system and remittance industry.

In contrast, the eruption of global financial crisis in 2008 had crushed the investor confidence and bank reputation. The currency crises and hyperinflation faced by countries like Venezuela, Zimbabwe and Bolivia have rendered their fiat currencies worthless. Subsequently, these currencies cannot be relied upon to act as disaster asset especially when the period of political instability strikes. Combining all the factors discussed, it is unsurprising that people start to consider cryptocurrency especially bitcoin as either mean of payment or part of their investment portfolio diversification.

However, despite the growing number of transaction volumes and bitcoin users as a whole, financial institutions and venture capitalists find it difficult to determine which international markets to invest and the appropriate investing strategies due to pseudonymous nature of Bitcoin. It is also proved challenging for governments and policy makers to enact sound administrative measure for bitcoin.

Thus, concerning the rising importance of cryptocurrency in the global economy and its potential mass adoption amongst nations, this paper focuses on constructing a country ranking index based on usefulness and potential utility of cryptocurrency brought to the market. This index aims to provide policy makers with insights on own strengths and weaknesses, while identifying the countries where the cryptocurrency market may prosper.

2. Literature Review

Crypto-finance world is a field filled with enticing prospects as it seems promising in many ways to challenge the incumbent banking and monetary system. It has gained a lot of attraction from investors and venture capitalist as more than 2.5 billion U.S dollars is being invested in terms of blockchain venture and Initial Coin Offering (ICO) in merely few years. In contrast, there is a minimal number of economics research regarding cryptocurrency. However, the amount of literature has been steadily increasing. As the rapid explosion of bitcoin in term of popularity and price continues, it is expected that more academic papers will be produced to expand knowledge in the field of cryptocurrency.

The main economic research in this field can be divided into three categories, which are 1) characteristics and nature of bitcoin, 2) volatility and pricing formation of bitcoin, and 3) application of bitcoin in real world cases. As one might notice, most findings are revolving around Bitcoin. At the time of writing, Bitcoin is the world's largest cryptocurrency in terms of market capitalizations and trade volume, followed by the alternative currencies (altcoin) like Ethereum, Ripple Coin, Dash and Litecoin. Thus, it is inevitable to generalize cryptocurrency as bitcoin on account of discussion in our context due to its incomparable influence.

Regarding the nature of Bitcoin, there has been a long debate discussing about what bitcoin should be. Theoretically speaking, Bitcoin can be seen as money from the view of Austrian economics although it does not fulfill the Mises' regression theorem. (Mazer, 2015) Some argues that it should be a mean of payment while others argue that it should act as store of value. In the papers written by Baur, Hong and Lee (2017) and Yermack (2014), it is concluded that Bitcoin is used mainly as a speculative asset. On the other hands, Bohme (2014)

had analyzed the plausibility of bitcoin as peer-to-peer payment and concluded that bitcoin is superior than current international payment system in aspects of capability, cost and speed.

There is a growing literature about the volatility and pricing formation of Bitcoin. Ciaian et al. (2014) studied the relationship between Bitcoin price and supply-demand fundamentals, global macro-financial indicators and Bitcoin's attractiveness for investors. The study finds out that the macro-financial indicators are statistically insignificant for Bitcoin price formation. Soldevilla (2017) concluded that there exists a bidirectional Granger-causality relationship between Bitcoin realized volatility and the CBOE Volatility Index (VIX) at 5% significance level. Davies (2014) summarized that changes in Google Trends of Bitcoin and Bitcoin price volatility affect each other.

As the awareness of bitcoin increases, more research is carried out to investigate the potential role of bitcoin in real life cases. In the paper written by Moore and Stephen (2015), Bitcoin is examined empirically to be part of international reserves in the case of Barbados. The result shows that Bitcoin has the potential to become key currency for transaction purposes and Central Bank of Barbados should hold a proportion of reserves in Bitcoin to avoid speculative attack. D'Alfonso and his colleagues (2016) examines the ideal investment strategy of including both Bitcoin and Ethereum into one's portfolio.

The objective of this paper is to improve on measure of Bitcoin utility ranking by countries done by Hileman (2014). This paper is the first attempt to produce the Bitcoin Market Potential Index (BMPI) that ranks bitcoin's potential utility across 178 countries. While this index has provided a good framework for future reference and better understanding of the factors behind bitcoin adoption, the writer acknowledged that there is certain limitation due to

insufficient data and ambiguous effect brought by regulations. Others than that, this paper missed out the variables that estimate the influence of political situation on Bitcoin adoption. Viglione (2015) investigated the case of Bitcoin as a possible disaster asset that can be used for diversification across jurisdictions with minimal costs, which suggesting that cryptocurrencies can behave as disaster assets for those in politically instable environments.

In essence, this paper aims to fill the gap left by works described above by constructing a more comprehensive bitcoin market potential index by using Principal Components Analysis. This paper also represents the first attempt to produce BMPI using dimension reduction method. We add in one sub-index, namely the political instability index and few variables which had insufficient data in the past. In the hope of answering the topic given, the results of the newly derived index will be compared with the Hileman's work, and then do country case studies to examine the relevance of our index in real-world basis. A correlation analysis will be carried out between the newly derived BMPI and GDP per capita to assess the association between income and likelihood of using bitcoin.

3. Conceptual framework of BMPI variables

Bitcoin is an interdisciplinary field situated itself at the intersection of social, political, technological and economic aspects. Hence, the selection of variable to construct Bitcoin Market Potential Index (BMPI) should be interdisciplinary as well. The variables discussed below are the eight dimensions representing different aspects where bitcoin can be useful.

3.1 Inflation

Inflation is another issue where Bitcoin is able to set in. While mild inflation is generally healthy to the economy, high inflation can erode the real income of labor. Subsequently it causes loss of confidence in domestic currency. As Bitcoin is a currency with finite supply like gold and silver, it is attractive to people in countries with high inflation level to invest in or even adopt it as alternative to fiat currency. Thus, we concur that bitcoin utility is positively correlated with inflation rate and create an independent sub index based on inflation.

3.2 Informal Economy

"Shadow economy is a perennial, multifaceted and hard to gauge phenomenon that affects to some degree all countries." —*A new multidimensional ranking of shadow economy for EU countries*

Given the evasive nature of informal economy, it is very difficult for the authority to regulate or even monitor these non-law-abiding activities. According to Medina and Schneider (2017), the shadow economy or black market includes all economic activities which are hidden

from official authorities for monetary, regulatory or institutional reasons. Based on this definition, we quantify the extent of informal economy by mostly using the dataset provided in their paper. In this context, we measure the size of informal economy as percentage of total economy.

Due to pseudo anonymity characteristic of Bitcoin, it is attractive for people who wish to circumvent government law or surveillance to adopt Bitcoin as mean of payment. However, this attribute has also attracted a lot of early adopters who are interested in illegal drug trade. One of the most prominent example is the misuse of bitcoin in Silk Road in early 2010s. Nonetheless, we argue that cryptocurrency brings more good than harm, as ethical use of cryptocurrency can potentially promote financial inclusion for those unbanked and underbanked households in countries with large underground economies.

3.3 Remittance

According to World Bank forecast in 2017, it is estimated that the total remittance flows to the developing countries would be a staggering amount of 444 billion dollar. The real figure could be much higher considering the informal cross border money transfer channels such as hawala system in Middle East is not being calculated. The remittance is an important lifeline to many third world countries as it promotes economic growth and poverty reduction immensely. (Pradhan et.al, 2017)

However, sending an international money transfer often comes with listed transfer fee and a hidden fee. The hidden fee is the foreign exchange markup, which represents the difference between generating quotes of the consumer exchange rate and the real-time market exchange rate. According to a survey research conducted by finder.com, the average exchange rate margin is 1.84% and this would result in estimated $8.17 billion spent annually in unknown fees.

While the trend in decreasing costs of remittance service worldwide continues, some regions are still benefited relatively less from it. The obvious example would be the Latin-American and Sub-Saharan regions, where the remittance cost is the highest among all.

With the emergence of blockchain technology, transferring money across the border through bitcoin can potentially disrupt the businesses of remittance companies such as Western Union, WorldRemit and MoneyGram. While the people spend 31.7 billion US dollar per year in fees to send money back home to relatives, bitcoin can provide an option for expatriates and foreign workers to remit their incomes quicker and cheaper.

As Bitcoin-based remittance startups can be useful for remittance market especially the niche one that is often neglected by big enterprises, data offered by world bank is used to measure utility of bitcoin in remittance. This sub index shall include both average remittance fee and personal remittance received by country. The personal remittance variable is further divided into two components, which are personal remittance by US dollar and personal remittance as percentage of GDP. This classification is necessary to recognize the importance of remittance to the country development.

3.4 Technology penetration

Technology penetration is defined as "the rate at which a specific technical innovation becomes adopted into the everyday life of individuals within a social group." (Encyclopedia of Information Technology Curriculum Integration) Based on this definition, three equally weighted components under this sub index are included. The first component rates the number of internet users per hundred people. The second component consists of number of mobile cellular subscription per hundred people while the last component calculates the number of fixed broadband subscriptions per hundred people. These components altogether provide an imperfect but still practical proxies to measure the internet coverage among citizens in certain country.

Although bitcoin transaction can be done offline using text message service and blockchain specialized satellite, online bitcoin transaction is still the most popular way of receiving and sending bitcoin. Lack of internet access can therefore impede the process of bitcoin adoption.

3.5 Financial Crises

As financial crises take a wide array of forms, Hileman (2014) categorizes it into four equally weighted variables: hyperinflation, currency crises, inflation crises and other crises episodes. The other crises episodes variable is further divided into external default, domestic default and banking crises.

As the number of financial crises increases in the country, it is logical that the citizens would gradually lose trust in the national currency for the failure of government to correct the market. Theoretically, this phenomenon will translate in the adoption of cryptocurrency.

3.6 Financial repression

Another financial aspect that will may realize mass adoption in bitcoin is economic repression.

According to Viglione (2015), countries which experience higher degree of price manipulation, greater trade barrier, stricter capital control or lack of independence in financial institution from government would be the prime candidates for bitcoin adoption. In essence, people in countries with higher than average economic repression now have an alternative way of transmitting funds out of currencies that are at risk of losing significant value through converting fund into cryptocurrencies.

In this context, Hileman's concept is used to construct financial repression sub index. It includes twelve equally weighted variables and seven sub-variables for the case of financial sector repression. The details of each variables are available in Hileman's paper and the appendix of this paper.

<u>3.7 Bitcoin penetration</u>

Bitcoin penetration index rates the exposure and awareness of bitcoin among public. This is reflected by five variables, which are global bitcoin nodes, bitcoin software client downloads, google 'bitcoin' search ranking, bitcoin VC investment and lastly, ease of using bitcoin in daily life sub-index. "Per capita" concept is applied in sub-variables to show relative bitcoin adoption between countries.

Notably, one of the most distinctive features in this paper compared with Hileman's paper is the introduction of "ease of using bitcoin in daily life" sub-index. This variable is useful in measuring the convenience of using bitcoin in acquiring good and services in daily basis. This variable involves combination of number of bitcoin auto teller machine (ATM) and number of merchant accepting bitcoins as payment by country. "Per square kilometer of land area" concept is applied to provide a better approximation of bitcoin merchant density.

3.8 Political repression

Viglione (2015) stated in his paper that *"… investors undergo a higher than normal degree of asset confiscation with limited legal ability to protect themselves by moving funds outside of the local currency, or political jurisdiction."* This statement presents potential utility of Bitcoin as Bitcoin is arguably one of the best way to pass fund internationally effectively without government interference.

Viglione elaborated further about the possibility of Bitcoin acting as a disaster asset in politically instable markets. The result of his paper has enabled the inclusion of political aspect in the BMPI. Hence the political stability index conducted by World Bank is included as one of the sub indices. The component should be self-explanatory as Bitcoin is most likely to be adopted in the least political stable countries.

4. Data sources and limitations

As the research aims to encompass as many dimensions as possible, a wide range of data is required to construct the variables for social, economic, political and technological aspects. This latest BMPI consists of all variables used by Hileman and newly added 2 variables which are deemed important. Most of the variables has been updated except for Financial Crises and Financial Repression variables due to data constraints. Thus, Hileman's rankings for both variables are used as the proxy data.

The data for variables is collected from various sources that are deemed trustable. They are mainly from Google Trends, IMF, CoinDesk and World Bank. Secondary data from the work of Reinhart and Rogoff (2010) and Hassan and Schneider (2016) are used. Reinhart and Rogoff provide the data for financial crises index while the paper of Hassan and Schneider has the latest dataset regarding shadow economy in 157 countries. A decision is made to choose this paper over Elgin and Oztunali's paper in 2012 as the former provides more recent data. However, Elgin and Oztunali's paper is used to complement some unavailable data in this context.

In order to include political factor in the index, ranking data from World Bank's Political Stability Index is used. Furthermore, number of merchant adoptions and Bitcoin ATM are being included in the "Bitcoin Penetration" sub-index. These data were previously unavailable but now one can get access to these information from the Coinmap.org or Coinatmradar.com. A further effort is made to manually count and record 10731 sites around the world that accept bitcoin payment.

As this paper aims to assess utility of bitcoin adoption on a global scale, an effort is made to include all relevant indicators for 178 countries. Nonetheless, problems arise inevitably due to insufficient data, especially in developing countries. For example, as mentioned by Hileman, while smartphone penetration data can be served as a more accurate variable for Technology penetration sub-index, the study conducted by Newzoo only reported for data of 50 countries in 2017. Other than that, the cultural dimension is not being included as there is insufficient research working on this topic. However, it is possible to identify the factors having an impact on the adoption of the bitcoin currency by using the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2). It is particularly interesting in understanding how different culture influence the adoption of a new technology by using this theoretical framework.

In order to solve cases of data inadequacy, several alternative sources such as KNOEMA company, CIA Factbook and Western Union are used to fill in the blanks of missing data. KNOEMA is a privately held company that specializes in data research while CIA Factbook provides resources contributed by Central Intelligence Agency of United States. Their data serve as substitute for the missing country level data of World Bank. As Western Union remains its position as the leader in remittance market, their data can serve as a proxy approximating the Remittance Sub-index.

As conclusion, this index has compiled data from multiple sources, including national statistics bureau, non-governmental organization, academic resources and corporations.

5. Index Methodology

"What is badly defined is likely to be badly measured." – OECD Handbook on Constructing Composite Indicators.

5.1 Defining BMPI

As there is no existence of theoretical framework regarding this topic, defining the term "Bitcoin Market Potential Index" (BMPI) is based on subjective evaluation. In this paper, it is defined as the total potential utility gained in a country by adopting bitcoin in all means. Thus, the scenarios of adopting bitcoin shall not just be constrained by replacement of local fiat currency. It can be the scenario where people adopt bitcoin by their own, thus forming a shadow economy, or the scenario where bitcoin becomes a parallel currency. BMPI also captures the possibility that country decides to make their own cryptocurrency, as long as the cryptocurrency has the similar characteristics with bitcoin. Additionally, most of the subsequent cryptocurrencies are based on the Bitcoin protocol and are variations on the same principle. Thus, studying Bitcoin will provide an accurate representation on the overall dynamics of cryptocurrencies.

As Bitcoin continues its dominance over the other cryptocurrencies such as Ripple, Ethereum and Litecoin, BMPI shall work as proxy in finding which country is conducive to adoption of cryptocurrencies as a whole.

5.2 Selecting the variables

Next, due to the interdisciplinary nature of Bitcoin, the variables should be carefully chosen from four aspects for their implications on bitcoin adoption, which are politics, social, technology and economy aspects. These variables can be categorized into eight dimensions,

which are inflation, shadow economy, remittances, technology penetration, financial crisis, financial repression, bitcoin penetration and political instability.

5.3 Imputation of Missing Data

Several imputation methods are carried out in BMPI data construction. It includes substitution, hot-and-cold-deck imputations and unconditional median imputation. Case deletion is neglected in this context because the omission of missing records from analysis may lead to bias and make comparison between countries impossible.

5.4 Index variable weighting

There are a number of weighting technique to construct the index, such as Equal Weighting (EW), Factor Analysis (FA) and Principal Component Analysis (PCA). Hileman has used Equal Weighting techniques in his BMPI research in 2014. For example, if the variable under a dimension has *10%* weight, then the *n* number of sub-variables would share the weight of $\frac{10}{n}$% each. This method is relatively simple to apply, and it implies that the impact is the same across all dimensions. However, one may encounter the problem of double counting if the variables are highly correlated to each other.

Thus, in order to group individual indicators according to their degree of correlation, alternative weighting scheme by using Principal Component Analysis (PCA) was carried out in this paper. This paper also represents the first attempt of constructing BMPI by using a statistical model. PCA method is useful in variable reduction as it accounts for the highest possible variation in the indicator set using the smallest possible number of factors. The factors

scores by sub-indices can be aggregated into the final BMPI by weighting each factor according to its relative contribution to the explanation of the overall variance of the factor used. Unlike equal weighting scheme, this approach is objective and depends on the proportion of explained variances.

In this paper, *standardization (z-score)* is used to rescale data into common scale before constructing the indices based on both Equal Weighted (EW) and Principal Component Analysis (PCA). Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity are used to measure the suitability of data for PCA prior to the practice.

$$I_{qc}^t = \frac{x_{qc}^t - min_c(x_q^t)}{max_c(x_q^t) - min_c(x_q^t)}$$

x_{qc}^t: raw value of individual indicator at time *t* for country *c*,

$\bar{c}$: average x_{qc}^t across countries

I_{qc}^t: standardized value of individual indicator at time *t* for country *c*

$\sigma_{qc=\bar{c}}^t$: standard deviation across countries at time *t*

Decomposition analysis shall be made to further examine the index by graph visualization. And lastly, the robustness of BMPI shall be assessed by using uncertainty analysis. This analysis involves the process of comparing the results of BMPI using different weighting schemes (PCA and EW). Comparison with Hileman's BMPI is made as reference to the index construction using Equal Weighted method.

Last but not least, the relationship between the BMPI index and Gross Domestic Product (GDP) related variable, namely GDP per capita is being investigated by plotting a scatter diagram. These variables are logarithmically transformed to reduce magnitude of data. The variables of sub-index using GDP measurement such as Size of Shadow Economy as percentage of economy and Proportion of Personal Remittances received in economy are removed prior to the analysis. Finally, correlation analysis between the variables is done by conducting different correlation tests.

6. Results

Table 1 shows the top 10 countries with the highest relative potential for bitcoin adoption according to Bitcoin Market Potential Index. The ranking from year 2014 is derived from the Hileman's paper while the ranking of 2018 is the result of this paper.

BMPI ranking (Equal Weighting Method)		
Year	2018	2014 (Hileman)
Ranking	Country Name	Country Name
1	Venezuela, RB	Argentina
2	Congo, Dem. Rep.	Venezuela
3	Ukraine	Zimbabwe
4	Nigeria	Malawi
5	Mozambique	United States
6	Argentina	Belarus
7	Suriname	Nigeria
8	Zimbabwe	Congo, Dem. Rep.
9	Thailand	Iceland
10	Turkey	Iran

(Table 1)

By using the same methodology of equal weighting, a comparison is made between Hileman's ranking and newly derived BMPI. The observation is that 5 countries which are Venezuela, Congo, Dem. Rep., Nigeria, Argentina and Zimbabwe have continued to stay in top

10 positions after 4 years. There is also new entry of countries in the top 10 ranking, which are Ukraine, Mozambique, Suriname, Thailand and Turkey. Among these countries, Thailand is the only South East Asian country in the top 10 ranking and shows great improvement from 52th to 9th. In contrast, Iran dropped from 10th to 81th in the latest ranking. The reason can be found in the decomposition analysis when we look into scoring of sub-index. Compared with 2014, Iran ranks lower in all aspects except for technology penetration. Thailand has ranked higher in all aspects except for inflation and bitcoin penetration score. Its rank at 61th in remittance score compared with 155th in 2014 has boosted its overall BMPI immensely.

Next, the result between top 10 country rankings of BMPI using different weighting methods

(EW and PCA) is shown in the table 2.

BMPI ranking 2018		
Methods	Equal Weighted	Principal Component Analysis
Ranking	Country Name	Country Name
1	Venezuela, RB	United States
2	Congo, Dem. Rep.	Germany
3	Ukraine	Netherlands
4	Nigeria	China
5	Mozambique	Venezuela, RB
6	Argentina	United Kingdom
7	Suriname	France
8	Zimbabwe	Singapore
9	Thailand	Sweden
10	Turkey	Canada

(Table 2)

Except for Venezuela, the remaining countries are all different between both rankings. Most countries in the top 10 BMPI ranking using EW method come from Sub-Saharan and Latin American Regions, while developed and high-income countries scored higher in the right-hand side ranking by PCA method. This reflects that the different weighting schemes have considerable impact on the construction of BMPI. A further analysis on the component scores of BMPI using Principal Component Analysis is needed to clarify and explain its differences compared with Equal Weighted method.

Multivariate Analysis by using Principal Components Analysis

      The objective of using PCA technique is to reveal how different variables change in relation to each other and explain the variance through a few linear combinations of data. Prior to the analysis, the data were standardized first to have zero mean and unit variance.

Descriptive Statistics

	Mean	Std. Deviation	Analysis N
Zscore(Inflation)	.0000000	1.00000000	178
Zscore(ShadowEconomy)	.0000000	1.00000000	178
Zscore(RemittancePrice)	.0000000	1.00000000	178
Zscore(Remittance)	.0000000	1.00000000	178
Zscore(RemittanceGDP)	.0000000	1.00000000	178
Zscore(InternetUser)	.0000000	1.00000000	178
Zscore(MobileSub)	.0000000	1.00000000	178
Zscore(FixedBroadband)	.0000000	1.00000000	178
Zscore(FinancialCrises)	.0000000	1.00000000	178
Zscore(FinancialRepression)	.0000000	1.00000000	178
Zscore(Nodes)	.0000000	1.00000000	178
Zscore(NodesPercapita)	.0000000	1.00000000	178
Zscore(Software)	.0000000	1.00000000	178
Zscore(SoftwarePercapita)	.0000000	1.00000000	178
Zscore(GoogleSearch)	.0000000	1.00000000	178
Zscore(VCFunding)	.0000000	1.00000000	178

Zscore(Merchantsnum)	.0000000	1.00000000	178
Zscore(MerchantnumLand)	.0000000	1.00000000	178
Zscore(PoliticalInstability)	.0000000	1.00000000	178

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.794
Bartlett's Test of Sphericity	Approx. Chi-Square	1985.264
	df	171
	Sig.	.000

Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were used to test the suitability of data for Factor Analysis purpose. The value of KMO is stated as 0.794 while the P-value of smaller than 0.05 is significant enough to reject the null hypothesis. Therefore, Principal Components Analysis should be carried out as there are intercorrelations between individual indicators.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.587	29.408	29.408	5.587	29.408	29.408	3.658	19.252	19.252
2	3.108	16.358	45.766	3.108	16.358	45.766	3.131	16.479	35.731
3	1.437	7.562	53.328	1.437	7.562	53.328	2.327	12.245	47.977
4	1.285	6.761	60.089	1.285	6.761	60.089	1.662	8.747	56.724
5	1.087	5.719	65.808	1.087	5.719	65.808	1.408	7.409	64.133
6	1.003	5.279	71.087	1.003	5.279	71.087	1.321	6.954	71.087
7	.948	4.988	76.076						
8	.728	3.831	79.906						
9	.697	3.667	83.573						
10	.630	3.315	86.888						
11	.552	2.907	89.795						
12	.471	2.481	92.276						
13	.453	2.387	94.662						
14	.371	1.952	96.614						
15	.212	1.116	97.730						
16	.193	1.014	98.744						
17	.105	.552	99.296						
18	.083	.435	99.731						
19	.051	.269	100.000						

Extraction Method: Principal Component Analysis.

(Table 3)

The table 3 shows the eigenvalues of the correlation matrix of the 19 individual indicators that compose BMPI. The factors with associated eigenvalues larger than one are chosen. Thus, a total of 6 factors is seleted and the factors are accounted for 71.09% of overall variance. The scree plot serves as visualization of factors associated with eigenvalues.

Scree Plot
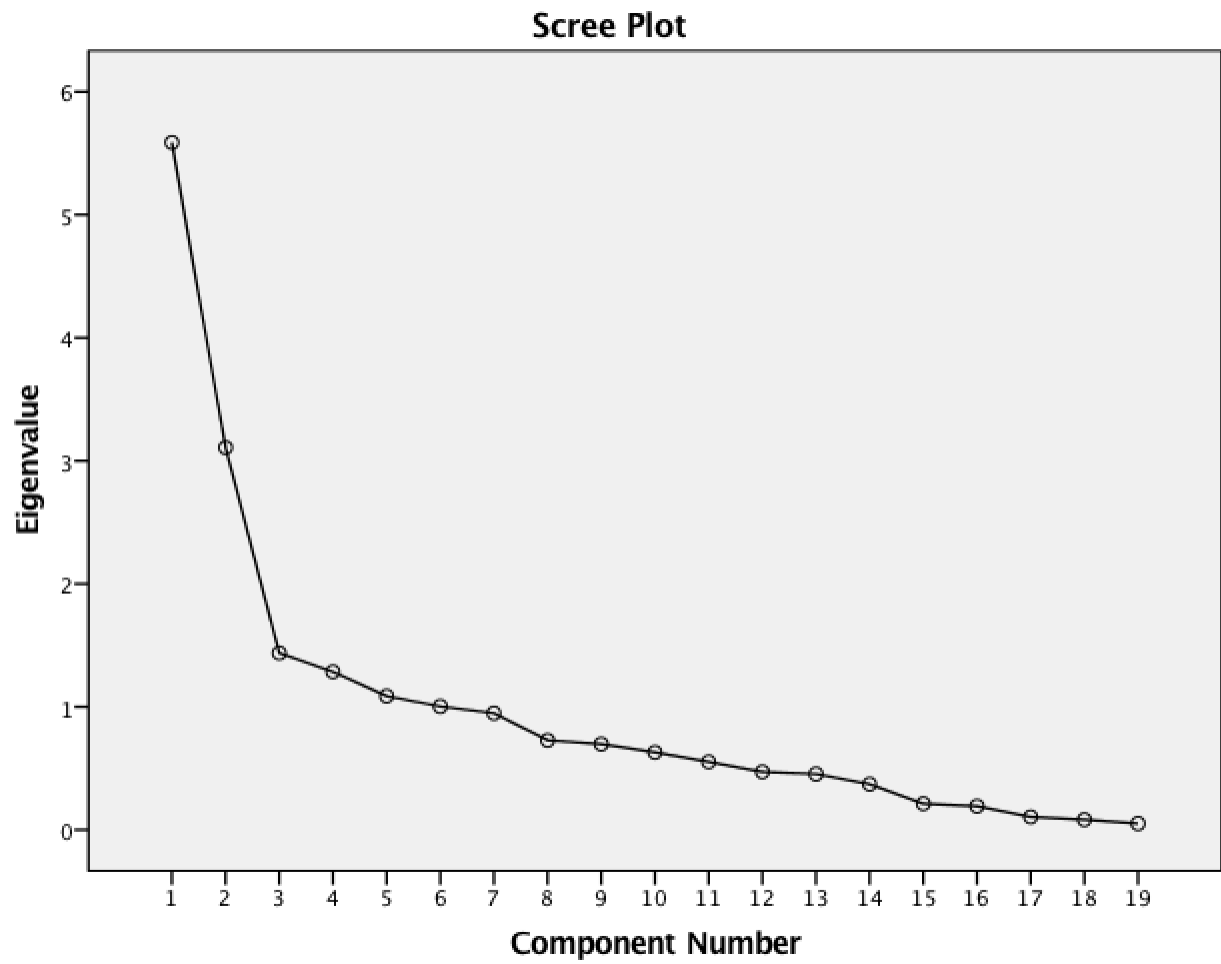
	Rotated Factor Loading					
	Component					
	1	2	3	4	5	6
Zscore(Software)	.952	.070	.105	.015	-.009	.131
Zscore(VCFunding)	.949	.019	.005	-.017	-.044	-.032
Zscore(Merchantsnum)	.916	.165	.092	-.001	.048	-.002
Zscore(Nodes)	.903	.081	.115	.129	-.028	.128
Zscore(InternetUser)	.087	.804	.431	.148	-.080	.097
Zscore(MobileSub)	-.038	.721	.112	-.023	-.198	.103
Zscore(FinancialRepression)	-.154	-.690	.059	-.116	.036	.160
Zscore(FixedBroadband)	.194	.673	.430	.346	-.041	.022
Zscore(SoftwarePercapita)	.199	.562	.428	.389	.036	-.140
Zscore(PoliticalInstability)	-.024	-.484	-.336	-.236	.334	.366
Zscore(RemittanceGDP)	-.052	-.102	-.716	.038	-.152	.046
Zscore(ShadowEconomy)	-.153	-.272	-.667	-.131	.130	-.186
Zscore(GoogleSearch)	.088	.231	.578	.331	-.206	-.069
Zscore(MerchantnumLand)	-.059	.045	.010	.831	-.163	.025
Zscore(NodesPercapita)	.131	.315	.200	.673	.078	-.036
Zscore(FinancialCrises)	.028	-.037	-.178	-.089	.789	.040
Zscore(Inflation)	-.046	-.169	.142	-.010	.700	-.010
Zscore(Remittance)	.168	-.141	.143	-.018	-.022	.831
Zscore(RemittancePrice)	-.021	-.398	.455	-.048	-.115	-.594

Rotated Squared Factor Loading (scaled to unity sum)						
	Component					
	1	2	3	4	5	6
Zscore(Software)	**0.25**	0.00	0.00	0.00	0.00	0.01
Zscore(VCFunding)	**0.25**	0.00	0.00	0.00	0.00	0.00
Zscore(Merchantsnum)	**0.23**	0.01	0.00	0.00	0.00	0.00
Zscore(Nodes)	**0.22**	0.00	0.01	0.01	0.00	0.01
Zscore(InternetUser)	0.00	**0.21**	0.08	0.01	0.00	0.01
Zscore(MobileSub)	0.00	**0.17**	0.01	0.00	0.03	0.01
Zscore(FinancialRepression)	0.01	**0.15**	0.00	0.01	0.00	0.02
Zscore(FixedBroadband)	0.01	**0.14**	0.08	0.07	0.00	0.00
Zscore(SoftwarePercapita)	0.01	**0.10**	0.08	0.09	0.00	0.01
Zscore(PoliticalInstability)	0.00	0.07	0.05	0.03	0.08	**0.10**
Zscore(RemittanceGDP)	0.00	0.00	**0.22**	0.00	0.02	0.00
Zscore(ShadowEconomy)	0.01	0.02	**0.19**	0.01	0.01	0.03
Zscore(GoogleSearch)	0.00	0.02	**0.14**	0.07	0.03	0.00
Zscore(MerchantnumLand)	0.00	0.00	0.00	**0.42**	0.02	0.00
Zscore(NodesPercapita)	0.00	0.03	0.02	**0.27**	0.00	0.00
Zscore(FinancialCrises)	0.00	0.00	0.01	0.00	**0.44**	0.00
Zscore(Inflation)	0.00	0.01	0.01	0.00	**0.35**	0.00
Zscore(Remittance)	0.01	0.01	0.01	0.00	0.00	**0.52**
Zscore(RemittancePrice)	0.00	0.05	0.09	0.00	0.01	**0.27**

(Table 4)

The table 4 above shows the rotated squared factor loading after being scaled to unity sum. Each value in the column adds up to value of 1. The number figures in bold font belongs to the individual indicators with the highest factor loadings. These individual indicators in each

component are then grouped into intermediate composite indicators. By applying this method, 6

intermediate composite indicators are grouped as shown in table 6.

Rotated Squared Factor Loading and Weightage for Each Factor						
	Component					
	1	2	3	4	5	6
Zscore(Software)	.91	.00	.01	.00	.00	.02
Zscore(VCFunding)	.90	.00	.00	.00	.00	.00
Zscore(Merchantsnum)	.84	.03	.01	.00	.00	.00
Zscore(Nodes)	.81	.01	.01	.02	.00	.02
Zscore(InternetUser)	.01	.65	.19	.02	.01	.01
Zscore(MobileSub)	.00	.52	.01	.00	.04	.01
Zscore(FinancialRepression)	.02	.48	.00	.01	.00	.03
Zscore(FixedBroadband)	.04	.45	.18	.12	.00	.00
Zscore(SoftwarePercapita)	.04	.32	.18	.15	.00	.02
Zscore(PoliticalInstability)	.00	.23	.11	.06	.11	.13
Zscore(RemittanceGDP)	.00	.01	.51	.00	.02	.00
Zscore(ShadowEconomy)	.02	.07	.44	.02	.02	.03
Zscore(GoogleSearch)	.01	.05	.33	.11	.04	.00
Zscore(MerchantnumLand)	.00	.00	.00	.69	.03	.00
Zscore(NodesPercapita)	.02	.10	.04	.45	.01	.00
Zscore(FinancialCrises)	.00	.00	.03	.01	.62	.00
Zscore(Inflation)	.00	.03	.02	.00	.49	.00
Zscore(Remittance)	.03	.02	.02	.00	.00	.69
Zscore(RemittancePrice)	.00	.16	.21	.00	.01	.35
Explained Variance	3.66	3.13	2.33	1.66	1.41	1.32
Explained Variable /Total Variance	.27	.23	.17	.12	.11	.10

(Table 5)

Explanation of the result of variables using PCA Weighting Scheme

       The table 6 below show the explained variance of each principal component. The first principal component accounts for the most variation of 3.66 while the second principal component accounts for variance of 3.13 and so on. The weight for each factor score is therefore the explained variance divided by the total variance of 6 factors combined. Thus, the weight of the first principal component is the 0.27 while the smallest weight of 0.10 is assigned to the sixth principal component. Note that the term principal component is interchangeable with the factor loading.

	Proportion of individual indicators to explained variation of each component	Weight of each component
Component 1	Zscore(Software)0.25	0.27
	Zscore(VCFunding)0.25	
	Zscore(Merchantsnum)0.23	
	Zscore(Nodes)0.22	
Component 2	Zscore(InternetUser)0.21	0.23
	Zscore(MobileSub)0.17	
	Zscore(FinancialRepression)0.15	
	Zscore(FixedBroadband)0.14	
	Zscore(SoftwarePercapita)0.10	
Component 3	Zscore(RemittanceGDP)0.22	0.17
	Zscore(ShadowEconomy)0.19	

	Zscore(GoogleSearch)0.14	
Component 4	Zscore(MerchantnumLand)0.42	0.12
	Zscore(NodesPercapita)0.27	
Component 5	Zscore(FinancialCrises)0.44	0.11
	Zscore(Inflation)0.35	
Component 6	Zscore(PoliticalInstability)0.10	0.10
	Zscore(Remittance)0.52	
	Zscore(RemittancePrice)0.27	

(Table 6)

By multiplying the weights with the factor score and aggregating all 6 weighted factor scores, the construction of PCA weighted BMPI is complete.

6.2 Back to the data comparison

By observing the table, it is safe to deduce that the reason of differences between both indices lies on the choice of assigning weight for individual variables. For instance, Political Instability indicator has a weight of 1/8 in BMPI using EW method, however it only shares 0.10 of weight with two other indicators in the component 6 in PCA. This has undoubtedly reduced the political influence towards the BMPI ranking.

Secondly, the individual indicators in component 1 also explain the existence of developed European and North American countries in the top 10 BMPI ranking. These high income countries mostly score well in bitcoin software download score, VC funding, Number of merchants and Bitcoin nodes variables. As the highest weight of 0.27 is being assigned for these indicators in first component, it explains why countries like United States, Canada and France are in the top 10 list in BMPI (PCA Method).

In essence, by going through the process of Principal Component Analysis, the weighting scheme is transparent and open to scrutiny. While most indices rely on Equal Weighting method, the risk of double counting exists as there may be high collinearity among the indicators chosen. The alternative statistical technique such as PCA provides a solution by grouping individual indicators according to their degree of correlation.

As BMPI measures the bitcoin's usefulness across 178 countries, the relationship between the economy and bitcoin is still unclear. While bitcoin is considered as possible tool of financial inclusion for the poor and unbanked population, its price volatility and the lack of bitcoin network infrastructure have impeded the process of mass bitcoin adoption in those countries in the Sub-Saharan and Latin American regions. In contrast, developed countries like United States and European countries own the most complete bitcoin-related network and modern technology infrastructure, thus rendering the idea of bitcoin adoption more feasible in these regions.

This notion can be further explained by Hileman, stating that *"… the question of how likely underbanked regions are to adopt cryptocurrency remains an open question and warrants further empirical research. But certainly one possibility is that it is the already-banked, not the unbanked, within countries with low quality financial services that will be the most likely to adopt cryptocurrencies."*

In order to investigate the correlation between income and usefulness of bitcoin, a simple scatter plot between natural log of BMPI index and natural log of GDP per capita is constructed below. All GDP-related variables used in constructing index are removed prior to the analysis.
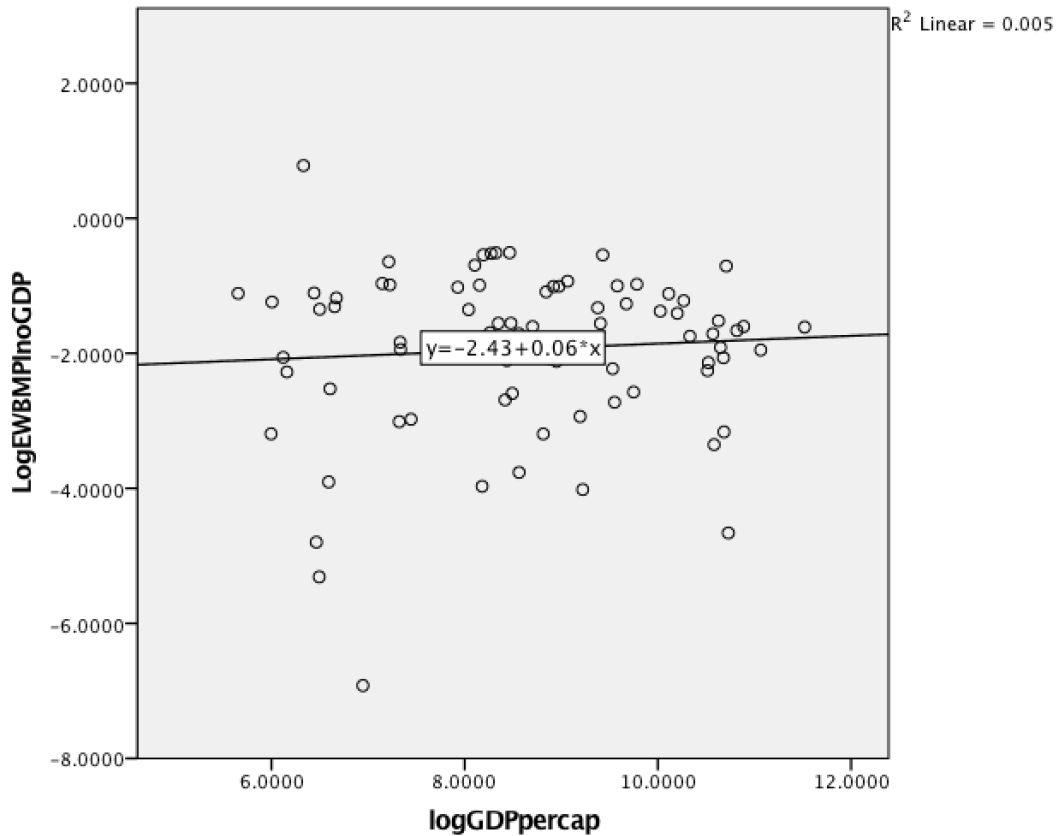
The Graph 1 above consists of log of GDP per capita and Log of BMPI using Equal Weighting method. The index used excludes GDP related variables.

Correlations

			LogEWBMPIn oGDP	logGDPperca p
Spearman's rho	LogEWBMPInoGD P	Correlation Coefficient	1.000	−.038
		Sig. (2−tailed)	.	.729
		N	84	84
	logGDPpercap	Correlation Coefficient	−.038	1.000
		Sig. (2−tailed)	.729	.
		N	84	178
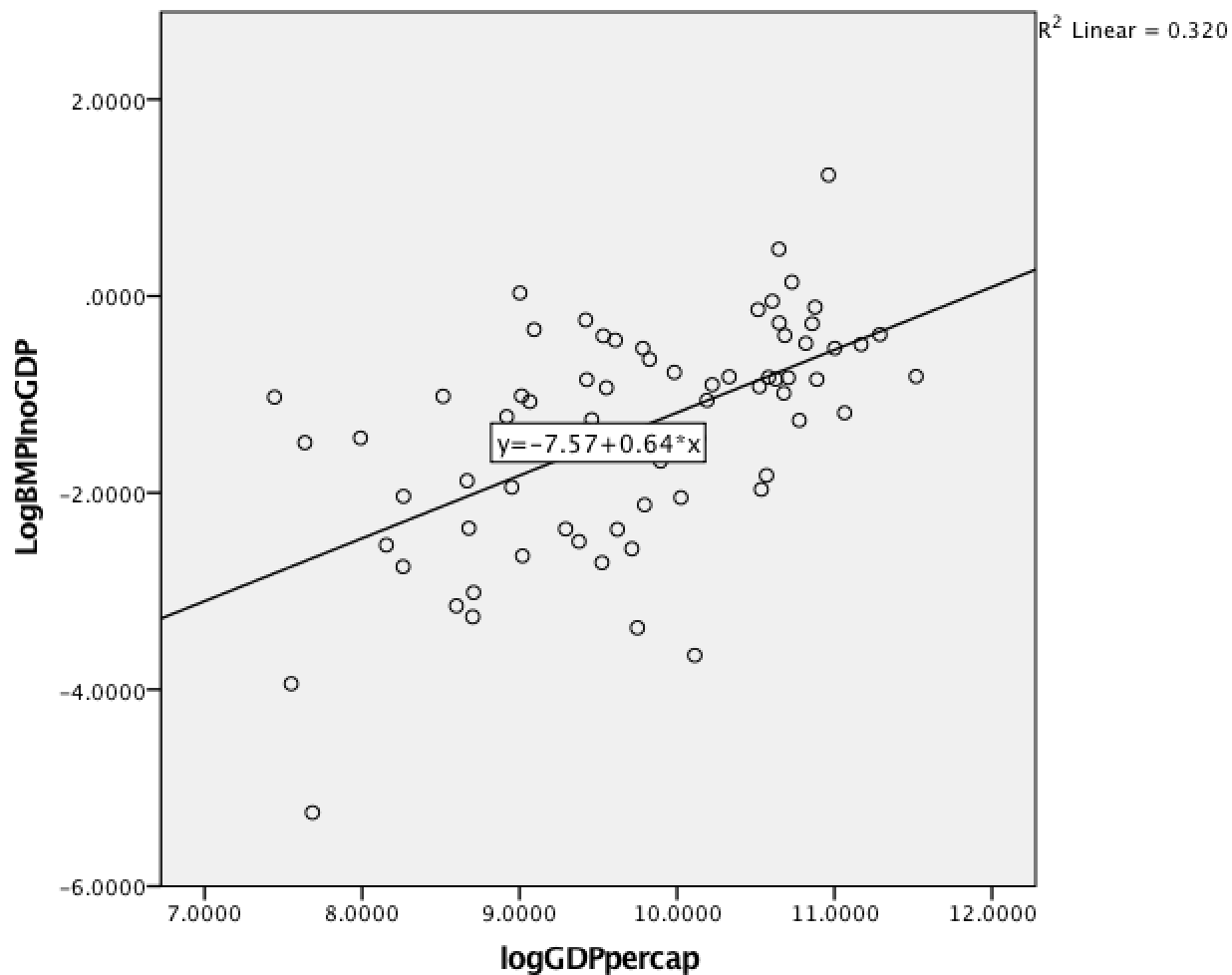
(Graph2)

The graph 2 above shows relationship between log of GDP per capita and Log of BMPI using

Principal Component Analysis method. The index used also excludes GDP related variables.

Correlations

			LogBMPInoGDP	logGDPpercap
Kendall's tau_b	LogBMPInoGDP	Correlation Coefficient	1.000	.396[**]
		Sig. (2-tailed)	.	.000
		N	72	72
	logGDPpercap	Correlation Coefficient	.396[**]	1.000
		Sig. (2-tailed)	.000	.
		N	72	178
Spearman's rho	LogBMPInoGDP	Correlation Coefficient	1.000	.576[**]
		Sig. (2-tailed)	.	.000
		N	72	72
	logGDPpercap	Correlation Coefficient	.576[**]	1.000
		Sig. (2-tailed)	.000	.
		N	72	178

[**]. Correlation is significant at the 0.01 level (2-tailed).

Correlations

		LogBMPInoGDP	logGDPpercap
LogBMPInoGDP	Pearson Correlation	1	.566[**]
	Sig. (2-tailed)		.000
	N	72	72
logGDPpercap	Pearson Correlation	.566[**]	1
	Sig. (2-tailed)	.000	
	N	72	178

[**]. Correlation is significant at the 0.01 level (2-tailed).

From the scatterplot of Graph 1 above, BMPI(EW)and income factor appears to have little to no correlation and yield statistically insignificant result based on p-value. However, as shown is Graph 2, BMPI using PCA method has a strong positive correlation with GDP per capita, and p-value is statistically significant based on computation of Pearson's, Kendall's Tau and Spearman's correlation coefficients.

As a result, it is suggested that people in high income countries are more likely to adopt bitcoin or bitcoin adoption is more likely to gain momentum in high income countries. While the causality between both variables remains unclear, the result largely reflects the reality as Bitcoin behaves more like a luxury for speculative investment rather than a global currency for now. (Yermack, 2014)

6.5 Limitations and Challenges faced by Bitcoin

Blockchain adoption is not without its challenges. There are four major problems that need to be solved in order to gain real traction among public and finance technology industry.

Scalability and Price Volatility

Due to the constraint of block size and finite number of miners on the network, the transaction confirmation time and network fee can spike up easily when the bitcoin network is congested as shown in chart below.
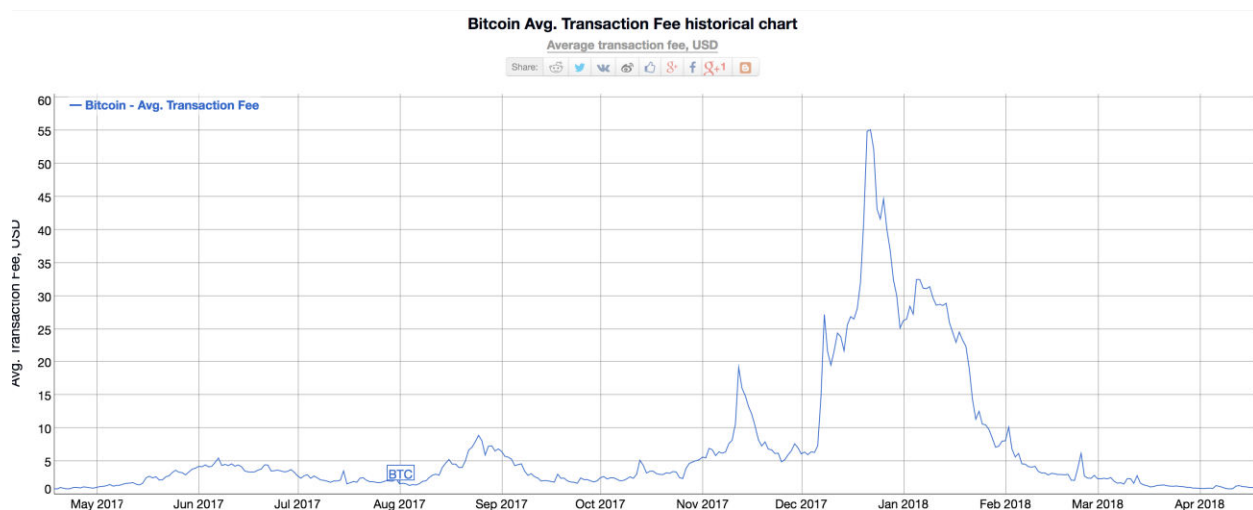
The chart above shows the average transaction fee in the period of May of 2017 to April of 2018.

Bitcoin Price in USD historical chart

Average price, per day, USD

Share:
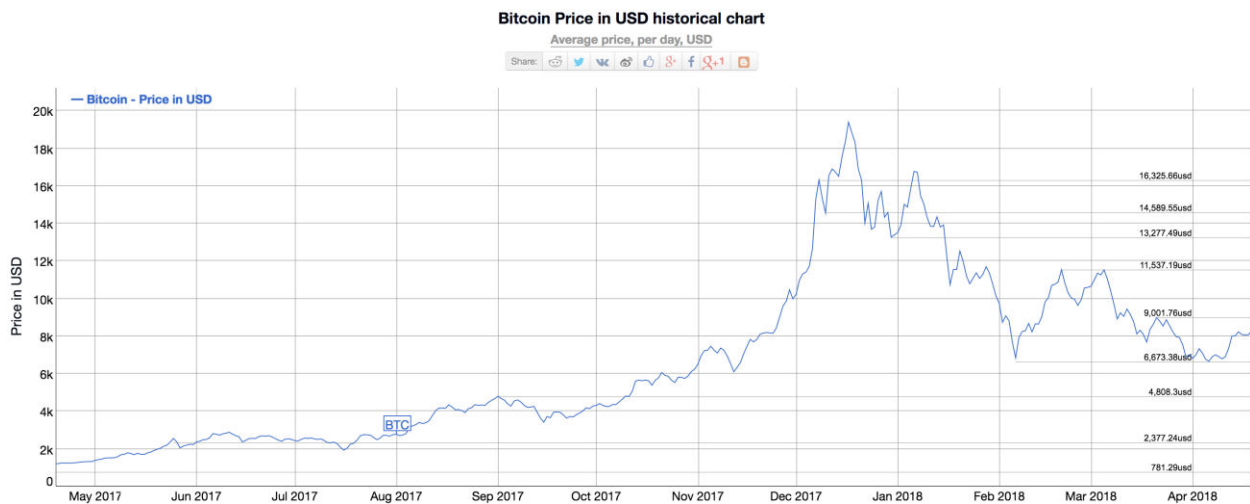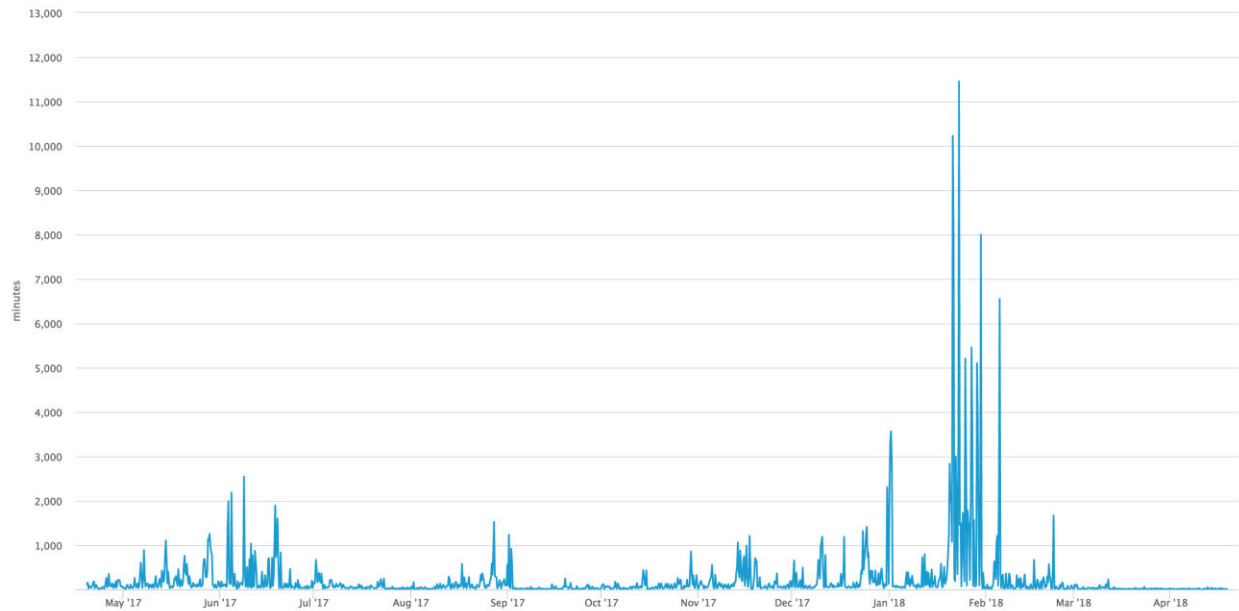
As implied from the charts[2] above, the price volatility is strongly correlated with the transaction fee. Although transaction fee returns to normal rate of 1 US dollar per transaction in 2018, the graph clearly shows that the transaction fee can rise rapidly especially when the bitcoin price was at historical high. The transaction confirmation time can also be painfully slow at times as opposed to bitcoin's claim of faster and cheaper payment.

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[2] The chart at the upper side shows the average transaction time waiting for first confirmation.

Competition

While the number of blockchain based startups continues to grow steadily over the years, almost none of them has risen to the challenge after the hype. For instance, Abra is a blockchain based remittance startup which was initially perceived as potential game changer in remittance industry. However, the fierce competition in the industry including traditional remittance company such as Western Union and MoneyGram and the likes of new FinTech non-blockchain based startup including WorldRemit, Transfer Wise and Remitly eventually drove Abra out of business. Abra has now pivoted its business from the original pitch of helping the unbanked population to becoming a digital wallet app for cryptocurrency investment.

Regulation and Compliance issue

The biggest challenge will be the regulation issue. As the enforcement of know your customer(KYC) and anti-money laundering (AML) remain ambiguous for the cases of cryptocurrency, legal compliance of cross-border remittance proved to be challenging for blockchain-based startups and Bitcoin. This is also the major reason why established company such as Western Union (WU) takes "Wait and See" approach in implementation of blockchain in the business. From the perspective of WU, the anonymity and potential problems of cryptocurrencies have outweighed the benefit brought by digital ledger technology. Nonetheless, Western Union has actively invested in the development of blockchain-based technologies throughout the years.

Deflationary pressure

As there will be only be theoretically 21 million bitcoin supply, the scarcity will drive up the Bitcoin price and it eventually causes the deflationary spiral. The impact can be detrimental for the economy as it disincentivizes the general demand from consumers and output from producers. However, this is based on the assumption that people use solely Bitcoin as replacement of fiat currency in the future. The emergences of other cryptocurrencies such as Ripple and Ethereum makes this statement questionable and thus requires further discussion.

7. Conclusion

In this paper, Bitcoin Market Potential Index is calculated using the two different weighting methods, namely Equal Weighting and Principal Components Analysis. This paper also represents the first attempt in constructing and comparing the differences between indices.

The detailed documentation of constructing BMPI using Principal Component Analysis may prove helpful for others to scrutinize the computation process and ensure the transparency in constructing index. The results of BMPI across 178 countries using different weighting approaches are compiled in the Appendix. BMPI aims to serve as reference for public in identifying which countries are more conducive to bitcoin adoptions.

In search of understanding relationship between potential utility of bitcoin and income variable, the correlation analysis is carried out between BMPI and GDP per capita in logarithmic scale. The result shows that BMPI is positively and strongly correlated to GDP per capita.

In short, the research questions of this thesis were successfully addressed through a variety of weighting methods. While the weighting of variables is essentially dependent on the subjective opinion or statistical method of analyst, the information presented in this work could be useful for investors, regulators, governments, private companies and academics that are interested in the primary factors of bitcoin adoption in certain countries.

Nonetheless, further research should be done in investigating causal relationship between BMPI and other macroeconomic indicator in the future. As the world of cryptocurrencies continues to evolve rapidly, other alternative cryptocurrencies shall be included to produce a more accurate index.

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Appendix A : Hileman's BMPI Ranking in 2014 using Equal Weighting (EW)

Hileman's BMPI Ranking in 2014							
	TOTAL	Inflation	Black market	Personal Remittances	Technology penetration	Financial crises	Financial repression	Bitcoin penetration
Argentina	1	1	136	146	46	2	31	52
Venezuela	2	2	105	59	91	8	26	71
Zimbabwe	3	21	1	33	124	6	53	139
Malawi	4	6	56	2	172	31	37	170
UnitedStates	5	132	177	92	28	107	164	1
Belarus	6	7	52	177	40	16	68	38
Nigeria	7	20	6	41	123	28	48	70
Congo,Dem.Rep.	8	126	15	98	169	1	51	173
Iceland	9	79	163	142	11	37	36	3
Iran	10	3	149	65	113	46	61	88
Russia	11	36	38	93	39	14	102	21
Guinea-Bissau	12	156	19	9	152	15	6	177
Sudan	13	5	139	49	137	4	112	160
Angola	14	18	50	29	147	7	42	142
Syria	15	4	144	42	142	155	16	152
Uruguay	16	19	17	55	31	10	160	68
Brazil	17	43	62	156	66	3	81	56
Serbia	18	25	67	90	67	38	28	42
Mozambique	19	75	61	6	166	17	21	157
Ukraine	20	172	16	143	73	36	44	34
Benin	21	146	9	14	138	82	1	150
India	22	12	143	1	143	83	8	64
Moldova	23	70	20	31	79	94	62	44
Tanzania	24	24	8	99	163	30	56	129
Congo,Rep.	25	47	25	10	130	98	38	153
Tunisia	26	46	72	57	96	115	11	85
China	27	99	173	7	93	96	28	4
Guinea	28	9	63	19	162	50	50	172
Nicaragua	29	30	23	158	115	12	76	122
Gabon	30	162	10	66	69	122	38	135
Bolivia	31	53	2	167	110	26	129	116
Bulgaria	32	149	101	82	49	22	89	26
Ghana	33	10	64	157	122	13	102	45
Barbados	34	120	40	139	42	155	19	90
Turkey	35	29	116	161	94	5	73	79
Coted'Ivoire	36	101	14	148	139	92	1	130
SriLanka	37	35	37	150	119	57	20	127
Chad	38	67	35	4	174	81	38	176
Swaziland	39	55	36	38	136	75	35	145
Suriname	40	118	85	168	90	29	16	104

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Burkina	41	159	53	18	156	103	1	166
Senegal	42	157	39	96	126	74	1	144
Jamaica	43	15	89	35	104	23	109	93
Poland	44	141	130	119	45	20	84	32
SouthAfrica	45	54	132	114	74	47	28	53
Lesotho	46	68	112	3	144	89	27	163
Algeria	47	86	103	84	116	54	5	98
Nepal	48	17	76	43	146	148	15	131
Niger	49	109	55	16	171	110	9	175
Peru	50	94	7	163	103	11	160	89
Morocco	51	119	95	71	80	97	16	86
Thailand	52	111	13	155	88	88	62	81
Tajikistan	53	66	27	26	131	69	69	146
Philippines	54	91	51	39	107	61	62	63
Namibia	55	56	119	23	117	93	21	119
Burundi	56	23	33	17	176	79	56	174
Dominica	57	174	40	106	58	155	59	37
Mali	58	176	49	83	118	122	6	165
SaoTomeandPrincipe	59	31	29	15	141	41	106	149
Comoros	60	108	34	8	165	129	42	169
Madagascar	61	50	65	45	173	40	34	154
Croatia	62	110	107	165	52	27	84	41
Aruba	63	178	40	147	30	155	51	77
St.KittsandNevis	64	154	40	94	18	155	75	101
Panama	65	77	5	171	62	77	147	57
Mexico	66	80	110	88	101	19	78	72
Haiti	67	48	4	27	149	55	164	147
Macedonia,	68	96	75	101	64	116	62	48
Azerbaijan	69	62	12	175	63	56	88	118
CostaRica	70	63	21	133	65	39	154	58
Seychelles	71	73	29	24	59	110	147	105
Bangladesh	72	28	88	91	154	148	12	75
Estonia	73	95	114	173	10	84	128	8
Belize	74	161	26	103	135	155	12	78
Uzbekistan	75	8	67	176	120	108	33	128
Lebanon	76	58	92	22	85	64	109	62
Romania	77	78	111	160	68	25	100	36
Zambia	78	34	32	36	145	18	168	158
Mauritania	79	33	109	11	132	129	54	117
Netherlands	80	103	169	124	6	135	168	2
Lithuania	81	144	113	107	24	78	120	18
Sweden	82	169	146	135	9	59	120	7

Israel	83	128	142	50	29	24	168	22
Colombia	84	114	90	169	87	21	73	80
Libya	85	81	102	60	95	129	44	138
Korea,Rep.	86	138	131	37	13	63	115	49
St.VincentandtheGrenadines	87	151	40	109	71	155	59	100
HongKongSARChina	88	71	166	70	1	148	156	13
SolomonIslands	89	37	91	67	157	129	21	162
Togo	90	122	73	80	158	122	10	148
Grenada	91	168	40	117	70	154	58	102
Botswana	92	76	98	5	99	120	86	120
Kazakhstan	93	49	71	178	37	65	81	65
SierraLeone	94	13	74	154	170	62	48	167
EgyptArabRep.	95	14	94	85	92	49	115	97
Myanmar	96	57	77	73	178	32	54	159
Bhutan	97	32	117	144	128	140	14	133
Cameroon	98	116	99	20	151	103	38	143
Ethiopia	99	22	83	151	175	86	21	161
Georgia	100	175	3	166	86	106	134	106
Guatemala	101	72	11	159	102	53	134	82
Germany	102	129	159	44	14	101	134	9
Honduras	103	65	18	108	127	52	109	126
Pakistan	104	26	86	125	148	145	47	76
Fiji	105	93	87	104	111	140	44	123
Samoa	106	158	77	12	177	110	31	136
Armenia	107	51	60	153	89	73	94	108
DominicanRepublic	108	69	104	123	105	34	94	60
UnitedKingdom	109	102	170	122	8	87	147	6
Norway	110	112	148	136	7	101	142	11
Slovenia	111	123	133	121	38	71	142	14
TrinidadandTobago	112	64	93	145	50	140	99	84
Iraq	113	41	125	53	133	35	77	140
Albania	114	117	96	89	78	66	94	50
Cyprus	115	173	127	137	61	148	71	27
Tonga	116	155	77	21	134	110	69	113
Ecuador	117	97	106	170	97	9	131	83
KyrgyzRepublic	118	38	58	86	109	79	120	111
St.Lucia	119	131	40	126	83	155	79	103
Malaysia	120	113	108	162	56	117	72	55
Finland	121	130	151	130	2	135	168	10
Curacao	122	107	40	141	82	155	83	177
Portugal	123	166	135	95	53	76	89	35
AntiguaandBarbuda	124	145	40	131	72	155	89	91

AntiguaandBarbuda	124	145	40	131	72	155	89	91
Bahamas,The	125	164	129	138	98	155	21	96
Cambodia	126	92	28	54	114	109	106	125
Montenegro	127	90	67	78	51	155	142	94
Malta	128	137	121	140	20	148	142	30
Guyana	129	89	84	28	121	70	101	124
Italy	130	140	122	87	26	99	134	43
ElSalvador	131	153	24	152	100	67	112	115
Laos	132	42	77	69	150	155	67	137
Denmark	133	152	152	127	4	117	147	20
Canada	134	147	162	129	27	135	147	5
Paraguay	135	98	57	102	108	33	160	110
Mauritius	136	82	140	25	77	91	102	87
Hungary	137	125	134	164	35	44	120	40
BosniaandHerzegovina	138	170	97	46	75	155	86	61
SanMarino	139	127	122	115	36	129	93	73
Gambia,	140	44	59	34	129	68	160	141
Australia	141	104	168	61	32	95	147	12
Latvia	142	167	128	174	23	84	120	23
Belgium	143	142	141	51	17	125	158	33
Vietnam	144	39	167	81	84	100	62	74
Singapore	145	105	172	72	15	135	147	17
Luxembourg	146	124	176	100	5	140	134	15
Greece	147	177	124	134	47	48	134	46
Switzerland	148	171	178	110	3	125	120	16
France	149	150	164	30	16	117	168	31
Uganda	150	61	54	79	160	60	115	151
Spain	151	135	137	68	43	114	141	39
Indonesia	152	40	147	118	112	45	79	66
Maldives	153	106	120	58	57	148	127	92
Chile	154	121	145	149	55	51	92	69
Qatar	155	88	165	48	33	155	98	59
Mongolia	156	16	161	113	106	43	94	121
CzechRepublic	157	134	153	116	44	90	164	19
Kenya	158	52	115	97	125	42	155	67
NewZealand	159	148	171	74	25	72	168	25
Austria	160	115	175	112	12	135	131	28
UnitedArabEmirates	161	143	138	63	21	155	168	54
PapuaNewGuinea	162	44	66	75	167	120	114	164
Djibouti	163	84	29	13	168	155	168	134
Japan	164	165	174	52	22	147	102	47
Liberia	165	58	22	105	161	129	164	168
BruneiDarussalam	166	163	100	76	76	155	134	99
Afghanistan	167	27	125	128	153	127	106	51

Rwanda	168	74	70	77	159	140	115	156
Ireland	169	160	160	132	41	103	168	24
Bahrain	170	87	156	47	19	155	168	107
Timor-Leste	171	85	77	40	164	155	119	171
Kuwait	172	100	157	64	34	155	130	109
SaudiArabia	173	83	158	56	48	155	131	95
SlovakRepublic	174	136	154	111	54	155	156	29
Yemen,Rep.	175	11	118	172	140	58	142	155
Oman	176	139	155	62	60	155	126	112
Vanuatu	177	133	77	32	155	145	178	132
Jordan	178	60	150	120	81	127	158	114

Appendix B: BMPI in 2018 using Equal Weighting (EW)

Country Name	TOTAL	Inflation	Shadow Economy	Personal Remittances	Technology Penetration	Financial Crises	Financial Repression	Bitcoin Penetration	Political Instability
Venezuela, RB	1	1	102	139	103	8	26	79	24
Congo, Dem. Rep.	2	3	1	118	178	1	51	155	8
Ukraine	3	15	27	97	80	36	44	77	11
Nigeria	4	13	48	23	140	28	48	54	12
Mozambique	5	21	13	57	161	17	21	148	23
Argentina	6	7	85	74	51	2	31	61	105
Suriname	7	2	110	151	77	29	16	81	110
Zimbabwe	8	175	14	30	138	6	53	82	46
Thailand	9	135	6	61	64	88	62	99	30
Turkey	10	29	98	143	91	5	73	70	10
Tanzania	11	49	7	25	159	30	56	108	59
Russian Federation	12	33	41	170	28	14	102	40	32
Ghana	13	12	20	82	106	13	102	49	76
Angola	14	4	134	4	168	7	42	138	62
Philippines	15	88	63	17	99	61	62	60	18
Benin	16	166	8	11	155	82	1	101	94
India	17	50	140	1	134	83	8	62	27
United States	18	103	178	133	29	107	164	1	114
Brazil	19	25	53	144	81	3	81	41	58
Swaziland	20	28	71	6	141	75	35	27	57
Malawi	21	8	46	18	175	31	37	142	87
Tajikistan	22	43	12	58	133	69	69	170	37
China	23	86	168	15	83	96	28	5	52
Lebanon	24	162	99	16	63	64	109	89	14
Moldova	25	40	21	54	73	94	62	96	70
Algeria	26	39	119	123	102	54	5	159	21
South Africa	27	41	109	121	87	47	28	24	81
Libya	28	5	107	135	123	129	44	151	7
Lesotho	29	38	96	3	125	89	27	64	72
Serbia	30	104	118	46	66	38	28	71	93
Burundi	31	45	34	90	173	79	56	145	9
Iraq	32	99	72	100	146	35	77	169	6
Guinea	33	27	26	48	154	50	50	167	60
Burkina Faso	34	148	31	51	152	103	1	166	29
Mexico	35	74	105	44	97	19	78	102	38
Nepal	36	24	35	24	126	148	15	85	36
Colombia	37	30	111	147	85	21	73	76	26
Senegal	38	115	32	96	132	74	1	150	71
Yemen, Rep.	39	9	62	89	151	58	142	175	2
Egypt, Arab Rep.	40	17	59	65	109	49	115	157	16
Tunisia	41	61	57	102	93	115	11	132	25

Honduras	42	77	4	91	128	52	109	158	66
Gambia, The	43	32	11	7	114	68	160	137	53
Guatemala	44	52	5	80	112	53	135	153	50
Belarus	45	19	65	175	34	16	68	111	98
Mali	46	176	38	107	129	122	6	165	15
Syrian Arab Republic	47	6	152	52	149	156	16	172	1
Sierra Leone	48	20	23	87	142	62	48	162	77
Bulgaria	49	161	88	101	58	22	89	42	91
Iceland	50	91	162	47	11	37	36	15	175
Namibia	51	35	95	2	121	93	22	51	134
Guinea-Bissau	52	92	154	13	167	15	6	178	54
Kazakhstan	53	14	22	177	53	65	81	147	92
Greece	54	163	58	20	46	48	134	68	80
Morocco	55	93	55	78	94	97	16	131	69
Pakistan	56	60	86	63	157	145	47	65	4
Cote d'Ivoire	57	118	54	159	117	92	1	114	31
Nicaragua	58	68	40	145	118	12	76	146	75
Jamaica	59	81	43	33	95	23	109	100	107
Bolivia	60	63	10	155	124	26	129	98	73
Azerbaijan	61	54	39	176	68	56	88	125	33
Gabon	62	85	28	64	92	122	38	152	84
Madagascar	63	37	44	115	177	40	34	136	61
Ethiopia	64	31	92	136	169	86	22	140	13
Albania	65	101	33	55	90	66	94	97	108
Bangladesh	66	46	49	77	143	148	12	118	19
Congo, Rep.	67	51	50	43	135	98	38	163	48
Haiti	68	16	24	8	166	55	164	129	42
Uruguay	69	22	18	137	32	10	160	112	166
Armenia	70	172	36	138	86	73	94	106	47
Peru	71	64	15	157	101	11	160	134	78
El Salvador	72	122	17	85	100	67	112	149	86
Korea, Rep.	73	109	89	103	9	63	115	67	101
Niger	74	137	52	62	174	110	9	168	22
Sudan	75	11	135	178	150	4	112	171	5
Poland	76	157	120	124	44	20	84	45	124
Myanmar	77	34	121	120	137	32	54	116	44
Kyrgyz Republic	78	128	44	29	104	79	120	156	43
Israel	79	155	142	76	30	24	168	32	35
Croatia	80	169	103	127	62	27	84	47	130
Iran, Islamic Rep.	81	26	156	140	96	46	61	160	39
Dominican Republic	82	95	47	92	110	34	94	110	112
Mauritania	83	97	61	9	145	129	54	164	40
Cambodia	84	72	19	26	119	109	106	105	102
Liberia	85	23	2	40	158	129	164	161	49

Ecuador	86	89	37	158	107	9	131	133	82
Lao PDR	87	96	3	21	162	156	67	113	122
Malaysia	88	84	67	117	60	117	72	52	97
Indonesia	89	66	143	88	105	45	79	90	65
Solomon Islands	90	156	9	95	163	129	22	141	123
Romania	91	174	108	152	76	25	100	53	109
Sri Lanka	92	56	151	109	111	57	20	127	96
Cyprus	93	173	94	35	22	148	71	36	127
Togo	94	114	60	60	160	122	10	126	74
Chad	95	62	163	19	176	81	38	173	20
Macedonia, FYR	96	147	114	112	74	116	62	56	63
Germany	97	127	161	50	16	101	135	3	136
Panama	98	116	16	154	59	77	147	86	118
Belize	99	164	30	98	127	156	12	84	95
Afghanistan	100	82	121	81	165	127	106	109	3
Slovenia	101	142	112	41	48	71	142	10	157
Barbados	102	168	56	106	39	156	19	37	152
Uganda	103	47	97	42	164	60	115	93	41
Paraguay	104	55	25	146	108	33	160	117	104
Sao Tome and Princi	105	48	82	36	136	41	106	174	106
Zambia	106	10	69	22	147	18	168	139	103
Cameroon	107	112	66	168	153	103	38	115	28
Kenya	108	42	126	84	139	42	155	88	17
Uzbekistan	109	18	104	174	116	108	33	144	67
Georgia	110	83	29	167	78	106	135	63	68
Vietnam	111	69	130	49	89	100	62	92	100
Hungary	112	129	132	69	40	44	120	58	132
Sweden	113	108	149	116	14	59	120	17	154
Chile	114	58	148	169	69	51	92	25	125
United Kingdom	115	119	172	93	10	87	147	7	115
Trinidad and Tobago	116	71	93	83	35	140	99	66	111
Guyana	117	117	91	53	131	70	101	128	89
Aruba	118	165	72	104	36	156	51	14	172
Botswana	119	59	129	5	88	120	86	39	165
Lithuania	120	110	137	134	27	78	120	18	137
Italy	121	144	100	105	49	99	135	33	113
Estonia	122	138	136	160	13	84	128	22	131
Hong Kong SAR, Chir	123	80	133	113	1	148	156	8	142
Costa Rica	124	141	68	149	56	39	154	107	135
Tonga	125	79	72	12	130	110	69	176	149
Papua New Guinea	126	36	87	31	172	120	114	74	56
Portugal	127	121	125	148	52	76	89	57	162
Bosnia and Herzegov	128	171	70	70	84	156	86	103	64
Denmark	129	133	146	32	5	117	147	28	143

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Comoros	130	178	42	67	170	129	42	177	90
St. Kitts and Nevis	131	158	72	125	25	156	75	72	129
Bhutan	132	53	90	99	122	140	14	124	155
San Marino	133	124	100	172	55	129	93	13	150
France	134	136	166	37	19	117	168	26	85
Latvia	135	139	144	163	37	84	120	34	116
Mongolia	136	125	139	128	115	43	94	50	140
Switzerland	137	151	177	56	3	125	120	9	174
Belgium	138	87	128	71	21	125	158	35	120
Montenegro	139	149	115	14	31	156	142	83	99
Grenada	140	90	72	131	79	154	58	80	159
Malta	141	123	138	34	18	148	142	11	164
Mauritius	142	107	131	73	67	91	102	94	163
Australia	143	102	167	94	33	95	147	12	153
Antigua and Barbuda	144	152	72	119	26	156	89	46	159
Dominica	145	134	72	72	72	156	59	91	167
Ireland	146	140	164	10	50	103	168	23	146
Bahamas, The	147	150	113	156	70	156	22	69	148
Norway	148	65	144	150	12	101	142	21	168
Rwanda	149	44	64	39	156	140	115	123	88
Spain	150	146	117	153	43	114	141	44	121
Curacao	151	78	72	111	65	156	83	31	172
Netherlands	152	131	158	142	6	135	168	4	147
Czech Republic	153	120	150	66	47	90	164	19	156
Samoa	154	100	121	59	144	110	31	130	169
Luxembourg	155	132	170	27	4	140	135	20	176
Fiji	156	57	127	79	113	140	44	120	141
Jordan	157	160	159	86	45	127	158	143	51
Austria	158	111	176	130	8	135	131	16	139
Seychelles	159	167	82	164	57	110	147	55	133
St. Vincent and the G	160	145	72	129	82	156	59	121	159
Maldives	161	126	153	108	24	148	127	59	117
Finland	162	130	141	38	17	135	168	29	151
Japan	163	143	164	75	15	147	102	78	158
Canada	164	98	157	126	38	135	147	6	170
Timor-Leste	165	170	51	114	120	156	119	154	83
United Arab Emirate	166	94	116	165	7	155	168	43	119
New Zealand	167	106	173	110	20	72	168	30	177
Slovak Republic	168	154	147	28	41	156	156	38	128
Singapore	169	153	171	166	23	135	147	2	178
Bahrain	170	75	169	173	2	156	168	75	34
St. Lucia	171	177	72	132	98	156	79	119	144
Kuwait	172	70	174	68	71	156	130	95	79
Saudi Arabia	173	67	155	162	54	156	131	135	55
Qatar	174	73	175	161	42	156	98	73	145
Brunei Darussalam	175	159	106	141	75	156	135	48	171
Djibouti	176	76	82	122	171	156	168	104	45
Vanuatu	177	113	121	45	148	145	178	87	126
Oman	178	105	160	171	61	156	126	122	138

Appendix C: BMPI in 2018 using Principal Component Analysis (PCA)

Country Name	TOTAL	Factor Score 1	Factor Score 2	Factor Score 3	Factor Score 4	Factor Score 5	Factor Score 6
United States	1	1	88	136	136	122	160
Germany	2	2	67	22	8	75	10
Netherlands	3	7	11	28	5	73	113
China	4	3	166	5	80	143	2
Venezuela, RB	5	171	144	1	23	1	93
United Kingdom	6	4	22	27	50	67	79
France	7	6	46	34	29	101	6
Singapore	8	146	100	126	1	119	41
Sweden	9	22	7	24	16	25	106
Canada	10	5	39	16	15	102	128
Switzerland	11	16	35	8	10	107	125
Chile	12	105	55	127	4	5	62
Russian Federation	13	8	10	145	147	10	11
Australia	14	11	30	11	32	76	126
Iceland	15	158	43	3	13	22	152
Norway	16	111	6	23	18	59	114
Hong Kong SAR, China	17	165	14	100	3	131	72
Lithuania	18	104	19	60	9	34	97
Estonia	19	152	3	42	22	55	85
Czech Republic	20	13	28	35	20	72	136
New Zealand	21	115	5	21	70	65	140
Austria	22	100	17	13	63	133	53
Denmark	23	66	18	10	60	90	159
Israel	24	51	24	51	79	21	102
Luxembourg	25	156	23	14	12	118	150
Poland	26	19	32	70	134	36	31
Slovenia	27	81	56	15	11	62	168
Italy	28	10	37	93	146	95	32
Belgium	29	73	33	38	38	112	26
Korea, Rep.	30	23	26	76	120	54	34
Latvia	31	143	8	84	33	69	48
Finland	32	63	13	19	46	104	162
Belarus	33	145	15	132	113	8	28
Spain	34	12	27	85	140	91	76
Mexico	35	39	110	71	119	41	4
Brazil	36	9	70	104	156	11	78
Ireland	37	52	64	9	14	77	174
India	38	117	178	2	59	138	1
Argentina	39	15	69	55	168	7	127

Hungary	40	102	34	61	102	52	80
Bulgaria	41	82	49	87	30	24	95
Romania	42	74	58	94	78	39	49
Japan	43	14	44	36	170	140	73
Croatia	44	114	48	73	58	47	82
Portugal	45	99	42	56	101	70	99
Malta	46	168	89	18	7	163	145
Bahrain	47	178	1	89	178	152	15
Colombia	48	43	81	98	143	20	22
Suriname	49	170	94	31	125	4	74
San Marino	50	176	131	158	2	153	25
Uruguay	51	120	4	143	157	15	154
Turkey	52	64	103	75	121	9	33
United Arab Emirates	53	172	2	79	173	151	57
Ukraine	54	20	85	144	73	12	20
Philippines	55	129	126	83	65	100	3
Greece	56	21	63	53	127	43	166
Azerbaijan	57	153	38	148	132	29	23
Kazakhstan	58	159	16	154	161	28	35
Sudan	59	110	101	149	103	3	14
Slovak Republic	60	71	50	25	95	154	146
Costa Rica	61	144	9	133	166	57	105
Seychelles	62	155	21	138	45	110	84
Egypt, Arab Rep.	63	118	99	134	129	31	8
South Africa	64	131	116	17	107	78	65
Serbia	65	123	87	66	94	64	64
Cyprus	66	148	77	20	39	142	142
Ecuador	67	90	62	152	117	18	75
Iran, Islamic Rep.	68	127	106	62	152	32	40
Indonesia	69	95	104	64	162	71	18
Qatar	70	175	41	32	171	170	37
Panama	71	137	20	151	164	84	68
Lebanon	72	106	82	124	81	79	24
Nigeria	73	112	160	54	43	30	7
Peru	74	77	40	161	144	17	96
Aruba	75	177	118	37	6	178	86
Macedonia, FYR	76	147	93	45	112	115	70
Saudi Arabia	77	167	36	91	176	148	30
Malaysia	78	151	73	49	159	127	69
Maldives	79	173	25	43	177	167	83
Trinidad and Tobago	80	164	57	52	160	139	103

Vietnam	81	136	108	59	135	126	13
Jordan	82	161	12	150	172	146	19
Georgia	83	121	29	165	67	106	42
Dominican Republic	84	97	83	141	88	53	58
Mauritius	85	150	66	41	167	117	135
Ghana	86	116	84	139	89	26	100
Paraguay	87	86	47	155	139	33	132
Barbados	88	157	97	29	35	171	94
Mongolia	89	124	107	57	104	83	108
St. Kitts and Nevis	90	166	60	50	154	164	87
Oman	91	169	31	92	174	169	43
Uzbekistan	92	135	111	125	86	74	16
Kenya	93	65	117	103	115	37	92
Sri Lanka	94	142	115	106	105	86	12
Bahamas, The	95	163	92	39	108	166	52
Algeria	96	139	127	63	151	46	45
Armenia	97	113	54	164	91	82	46
Brunei Darussalam	98	154	61	47	155	174	124
Thailand	99	59	80	140	163	89	55
Curacao	100	160	98	26	47	176	112
Bolivia	101	78	75	159	87	27	117
Kuwait	102	162	71	30	175	161	91
Yemen, Rep.	103	44	114	166	51	13	27
Myanmar	104	108	135	82	118	38	77
Antigua and Barbuda	105	174	45	67	148	177	88
Nicaragua	106	92	79	163	99	35	67
Jamaica	107	75	68	160	56	66	115
Moldova	108	89	59	168	31	98	71
Pakistan	109	84	165	96	36	129	5
Grenada	110	149	96	46	130	150	110
Zambia	111	40	119	86	138	16	176
Albania	112	101	76	142	110	81	131
Morocco	113	138	112	113	133	116	21
Libya	114	132	143	78	142	48	38
Montenegro	115	125	52	88	158	175	148
Guatemala	116	61	65	169	92	58	56
Iraq	117	70	141	119	126	23	66
Dominica	118	126	74	110	74	172	116
St. Vincent and the Grena	119	133	95	65	141	159	111
Angola	120	53	177	12	96	6	172
Bosnia and Herzegovina	121	107	90	131	90	160	59

Tunisia	122	140	121	102	145	113	36
Congo, Dem. Rep.	123	27	161	156	27	2	147
El Salvador	124	83	51	172	85	97	51
Cote d'Ivoire	125	134	130	107	131	96	39
Guyana	126	60	120	130	77	80	134
Uganda	127	48	146	95	71	61	138
Cameroon	128	103	142	115	82	87	44
St. Lucia	129	119	105	80	137	165	118
Sao Tome and Principe	130	56	122	128	116	56	158
Botswana	131	141	132	6	165	162	173
Ethiopia	132	79	163	97	62	60	50
Bangladesh	133	109	158	105	49	137	9
Honduras	134	36	78	174	34	63	81
Fiji	135	128	129	48	150	149	120
Syrian Arab Republic	136	94	174	33	100	85	29
Swaziland	137	91	175	7	44	109	163
Afghanistan	138	58	153	99	98	94	60
Madagascar	139	45	159	121	41	40	122
Zimbabwe	140	41	136	153	37	49	137
Mozambique	141	50	156	122	66	14	149
Kyrgyz Republic	142	47	53	176	42	121	63
Sierra Leone	143	76	137	129	109	50	144
Vanuatu	144	57	125	74	122	147	164
Bhutan	145	122	139	58	123	145	119
Gabon	146	130	113	101	169	124	133
Malawi	147	31	173	44	55	19	171
Guinea	148	54	151	111	106	44	156
Guinea-Bissau	149	46	170	69	84	51	141
Burundi	150	34	168	123	54	45	101
Senegal	151	85	128	162	48	99	54
Djibouti	152	32	134	137	57	141	129
Samoa	153	88	150	68	97	136	139
Papua New Guinea	154	38	167	40	68	114	165
Tanzania	155	30	154	109	76	42	170
Cambodia	156	69	123	108	149	120	169
Belize	157	87	149	114	25	155	107
Timor-Leste	158	98	102	145	153	168	109
Namibia	159	93	171	4	128	132	178
Rwanda	160	35	148	90	114	128	161
Haiti	161	17	109	175	17	68	143
Congo, Rep.	162	80	147	120	124	105	130

Chad	163	29	169	118	40	92	89
Tajikistan	164	33	91	177	26	88	61
Mali	165	96	145	147	111	123	47
Gambia, The	166	25	72	173	83	93	167
Lesotho	167	72	155	72	61	130	157
Togo	168	67	157	117	52	135	104
Tonga	169	37	124	157	53	144	155
Niger	170	49	176	77	75	103	121
Burkina Faso	171	62	162	116	93	108	123
Nepal	172	68	133	171	19	173	17
Solomon Islands	173	55	152	135	64	134	153
Benin	174	42	172	81	72	111	175
Mauritania	175	28	140	167	28	156	98
Liberia	176	18	86	178	21	125	151
Comoros	177	24	138	170	24	158	90
Lao PDR	178	26	164	112	69	157	177