Research Paper Informatization Policy Vol. 27, No.2 (2020), pp.020-039
https://doi.org/10.22693/NIAIP.2020.27.2.020

Distributed Ledger Technology and Cryptocurrency Market Potential Index*

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Abstract This paper introduces the Cryptocurrency Market Potential Index (CMPI) in order to measure the potential of the blockchain-backed cryptocurrency. Adopting the Distributed Ledger Technology (DLT) system as a conceptual framework, the whole process from development to implementation and adoption of blockchain-backed cryptocurrency are examined. This paper selects 30 variables and employs factor analysis for multivariate analysis to produce the CMPI for a total of 213 countries. The results show that although cryptocurrency is decentralized, its development and usage might still be very centralized in Europe, North America, hotspots in the Asia-Pacific, Middle East, and CIS regions. This result also highlights how important development and implementation are before adoption so that consequent financial transactions can take place.

Keywords : cryptocurrency, distributed ledger technology, blockchain, index, factor analysis

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요 약 본 논문은 분산원장기술을 기반으로 하여 암호화폐시장 잠재력지수를 개발하였다. 이 지수의 최대장점은 암호화폐의 개발과 실행 그리고 확산에 이르기까지 암호화폐시장의 전반적인 잠재력을 측정, 비교할 수 있다는 것이다. 본 논문은 암호화폐시장 잠재력지수의 개발과 측정을 위하여 요인분석기법을 이용한 213개 국가의 30개 변수를 분석 비교하였다. 그 결과 암호화폐의 분권화에도 불구하고 그 잠재력은 유럽, 북미, 아시아에 속한 일부 선진국, 그리고 일부 중동국가와 구 소련의 독립국가연합에 집중되어 있음을 밝혀내었다. 이는 암호화폐시장의 발전을 위해서 암호화폐의 확산 이전에 개발과 실행과정이 선행되어야 함을 보여준다.

주제어 : 암호화폐, 분산원장기술, 블록체인, 지수, 요인분석

Received Mar 9, 2020; Revised Apr 16, 2020; Accepted Apr 17, 2020

* In preparing this paper, we have had the substantial benefit of the comments from two anonymous referees. This paper is a revised version of Nguyen's dissertation. Financial support from Korea University is gratefully acknowledged

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Ⅰ. Introduction

Blockchain technology, alongside machine learning and artificial intelligence, is powering the Fourth Industrial Revolution which is combining the physical, digital, and biological worlds to fundamentally change the way humans live(Schwab, 2015). The financial sector is one sector in which blockchain technology promises to fundamentally change through cryptocurrency, such as Bitcoin. Cryptocurrency backed by blockchain technology is playing a key role in the Fourth Industrial Revolution by offering a new and innovative way to establish trust and verification and to change how financial transactions are conducted.

There have been numerous studies on the cryptocurrency and its key functions (Luther & White, 2014; Brandvold, et al., 2015; Cheah & Fry, 2015; Carrick, 2016; Dyhrberg, 2016; Ji & Chun, 2016; Oh & Nguyen, 2018; Panagiotidis, et al., 2018; Sovbetov, 2018 etc.). This growing research interest can also be seen with the Bitcoin Market Potential Index (BMPI, Hileman, 2015) and the Blockchain Readiness Index (BRI, Vlachos, et al., 2019) which both attempt to measure the potential of this new technology. These two indexes however focus on a very specific aspect of blockchain-backed cryptocurrency and are hence limited. The BMPI is limited to only analyzing Bitcoin, and its factors are mainly related to demand and need by those who can benefit from financial inclusion. Similarly, BRI has also been proposed but not actually carried out fully to measure blockchain potential.[1)]

This paper seeks to improve on these two indexes with more thorough variables and a statistical approach known as factor analysis to introduce the Cryptocurrency Market Potential Index (CMPI) for a total of 213 countries. Furthermore, this paper focuses on where blockchain-backed cryptocurrency as a whole, from its development to people using it, has the most potential. In order to look at cryptocurrency potential from this whole perspective, each country's potential for development, implementation, and adoption and usefulness of this new type of currency is examined. Furthermore, rankings and weights are provided using factor analysis as multivariate analysis to compile the CMPI.

This paper proceeds as follows. Literature review is in chapter II. Chapter III introduces the CMPI framework and chapter IV defines data, variables, and methodology. The results are provided in chapter V and the concluding remarks in chapter VI.

Ⅱ. Literature Review

Since our society has entered a new stage known as the information society, there have been a large amount of literature on objective measuring indexes to facilitate meaningful comparisons and establish national and international goals to achieve the broadest and most effective

1) Furthermore, both indexes do not consider the technical components in relation to adoption. Hence, they are limited not only by looking at one cryptocurrency, but also by not looking at the whole picture from start to finish, from development to implementation and adoption.

implementation of the information revolution.[2)]

There also has been some attempts to index blockchain technology and related cryptocurrency. The BMPI is the first attempt providing a composite index, however, it is limited to just Bitcoin.(Hileman, 2015). The BMPI included 40 variables over 7 equally-weighted sub-indexes across 178 countries. The sub-index for the BMPI include inflation, black market, remittances, technology penetration, financial crises, financial repression, and bitcoin penetration. These were gathered from a mixture of private companies, governmental, multinational agencies, and academia. Viewing the sub-index there seem to be two main categories where technology penetration and bitcoin penetration represent the ability for each country to adopt Bitcoin whereas the other sub-indexes represent the need for each country to adopt Bitcoin. It seems the BMPI is based heavily on the need for Bitcoin in countries with high inflation, high remittances, informal economy, and financial repression. This research will seek to add to this type of index by incorporating it beyond Bitcoin and using a conceptual framework to modify the sub-indexes to include more variables that measure potential based on development and implementation also while taking into consideration the technical details of blockchain technology in cryptocurrency. Hence, the CMPI better measures cryptocurrency potential as a whole and its results reflect those of real-world conditions.

Another similar research is the BRI proposed by Vlachos, et al.(2019). The BRI is meant to serve as a tool to monitor the level of blockchain maturity based on suitability to host blockchain-based activities and adopt a blockchain regulatory framework. Compared to the BMPI, the BRI focuses on development and implementation more so than just adoption and usefulness by considering government regulation and the existing technology, research, and industry. Preliminary results were calculated using cosine similarity to a nonexistent ideal reference country. However, cosine similarity is not commonly used in constructing composite indexes and is more so used in machine learning to assess similarities between documents.

Whereas the BMPI top ten had mostly Sub-Saharan Africa and Latin American countries, the BRI contains mostly European countries along with the United States, Canada, and Singapore. Hence there is dichotomy between development and implementation versus that of adoption and usefulness. However, there currently lacks a literature that analyzes blockchain-backed cryptocurrency in general and considers all development and implementation with adaptation based on a country and global level.

The CMPI seeks to consider both aspects used in the BRI and BMPI and apply it to other cryptocurrencies as well. Furthermore, the factor analysis as multivariate analysis is employed to provide rankings and weights to compile the CMPI. This paper seeks to extend the BMPI and BRI to include other cryptocurrency, Ethereum as well. In addition, it goes beyond just the adoption and usefulness for cryptocurrency, and rather

2) Refer to OECD (1993), DTI (1996), IDC/World Times (1996, 1998), Oh (2000), Seo (2017) and Shin (2018) for details.

〈표 1〉 CMPI, BMPI, BRI 비교표
〈Table 1〉 CMPI, BMPI, and BRI Comparison

Index	Goal	Framework	Analysis Method
CMPI	Measure potential in terms of development, implementation, and adoption	DLT Systems Framework	Factor analysis to determine weights of 30 variables under 3 main sub-indexes
BMPI	Measures adaption/usefulness of Bitcoin	None	Seven equally weighted sub-indexes covering 40 variables
BRI	Blockchain maturity according to their suitability on hosting blockchain-based activities	Other regulation indexes and other technologies readiness index	Cosine similarity under five pillars of government regulations, research, technology, industry, and user engagement.

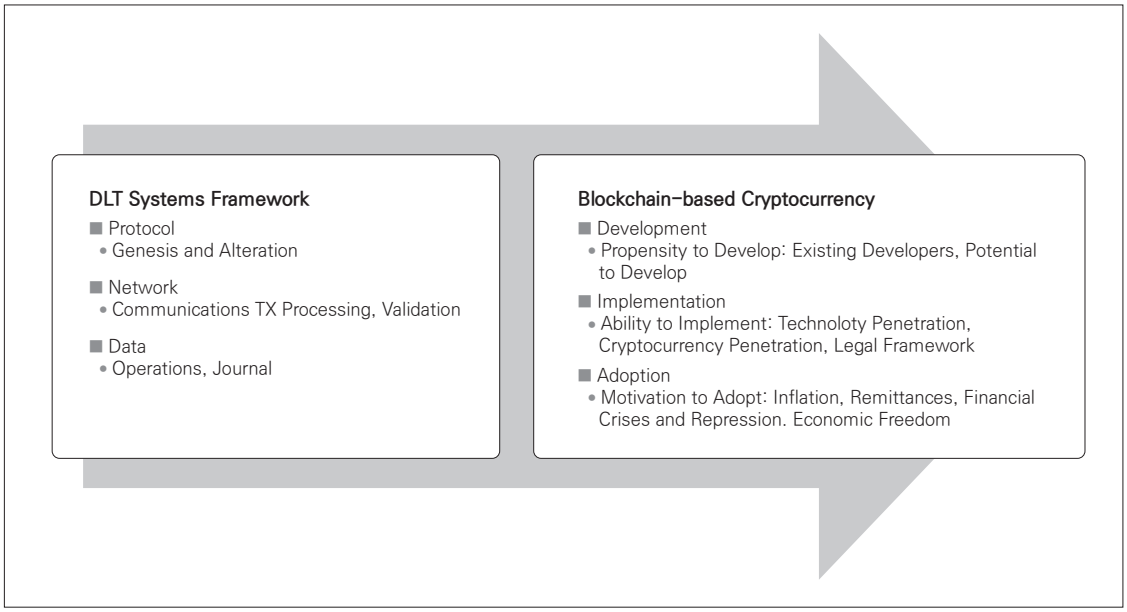
incorporates development and implementation to fully measure potential. 〈Table 1〉 is for the comparison of CMPI, BMPI, and BRI.

Ⅲ. The CMPI Framework: Distributed Ledger Technology (DLT) System

In order to understand the cryptocurrency ecosystem and examine how it is developed, implemented, and adapted, a conceptual framework is needed so that the CMPI can be constructed with accurate sub-indexes and variables. The Distributed Ledger Technology (DLT) system is chosen for the conceptual framework of CMPI, as it breaks down the blockchain technology behind cryptocurrency while considering the protocols, networks, and data involved in maintenance and usage of the technology. This allows for the consideration of factors involved, from development all the way to implementation and adoption.

Using Rauchs, et al.(2018)'s suggestions, DLT system is defined as a system of electronic records that enables a network of independent participants to establish a consensus around the authoritative ordering of cryptographically validated transactions. These records are made persistent by replicating the data across multiple nodes and tamper-evident by linking them through cryptographic hashes. The shared result of the reconciliation and consensus process, known as the ledger, serves as the authoritative version for these records.

There are three layers in the DLT system defined as the protocol, network, and data. The protocol layer is the set of formal rules that governs the system and has a genesis and alteration component. The network layer involves collectively storing, sharing, and processing data among the actors and consists of communications, transactions processing, and validation component. Lastly, the data layer refers to information processed and stored by DLT system and comprises of the operation and journal component. In short, the protocol gives the rules of the whole system, the network deals with network consensus, and lastly the data refers to the meaning of the data itself involved.



〈그림 1〉 분산원장시스템을 이용한 암호화폐 잠재력측정
〈Fig. 1〉 From DLT System to Measuring Cryptocurrency Potential

This framework helps the CMPI have an advantage over the BMPI and BRI as it is looking at cryptocurrency as a whole from development to implementation and adoption.[3] In addition, the DLT system framework provides a framework for categorizing and deriving the elements that come together to make blockchain-based cryptocurrency function. In other words, the DLT system framework gives an idea of what variables in the CMPI are to be included beyond just the people using cryptocurrency, to also who is developing it and who is implementing it.

This paper takes the protocol, network, and data layers from DLT systems in order to apply them to blockchain-based cryptocurrency. When that is done, protocol responds to development, network to implementation, and data to adoption as shown in the 〈Fig. 1〉. Hence, sub-indexes, variables, and sub-variables of the CMPI are developed from DLT system framework to index the potential of blockchain-backed cryptocurrency.

Ⅳ. Data, Variables, and Methodology

In constructing the CMPI, variables selected were taken into consideration after intensive review of the Bitcoin Market Potential Review (BMPI) and the Blockchain Readiness Index (BRI). The BMPI's variables were deemed to be

3) The BMPI just focuses on adoption, while the BRI focuses on adoption and only some elements of development but not from the DLT system framework.

important to Bitcoin's adoption and self-evident to those familiar with Bitcoin, such as Bitcoin being fundamentally a software technology and looking at internet use and mobile penetration for Bitcoin's potential for adoption in any given country (Hileman, 2015). The BRI examined the "Blockchain and Cryptocurrencies Regulation Index 2018" to arrive at five pillars-government regulation, research, technology, industry, and user engagement-to select variables such as legal status, internet access, acceptance rates, and bitcoin core downloads (Vlachos, et al., 2019).

For the CMPI, a more robust framework was used with the Distributed Ledger Technology Systems Framework and the variables selected were the direct consequences the protocol, network, and data layers defined. The protocol layer involves genesis and alteration of the blockchain technology so variables related to the number of developers and potential to develop were selected. The variables selected were done so with the layer and its components in mind while assessing the availability of data. Hence the number of developers' variables were selected based on the data available from Dappros while potential to develop variables, competitiveness and innovativeness, were selected due to the availability from the World Economic Forum and World Intellectual Property Organization while fitting with the nature of the protocol layer. The same was done with the network layer which involved communications, transaction processing, and validation components that had to do with implementation of blockchain-backed cryptocurrency and so technology penetration-related variables were selected with data availability from the World Bank and the International Telecommunication Union. Similarly, this also played a large role in selecting variables for the data layer which involved the operations components for exchanging financial information and motivation for adoption of blockchain-backed cryptocurrency. These included variables indicating why people would want to adopt cryptocurrency due to inflation, crises, and repression. Furthermore, variables of interest in blockchain-backed cryptocurrency were determined using Google Trends search of Bitcoin and Ethereum, and how many Bitcoin and Ethereum software were downloaded.

In total, these 30 variables were constructed from the DLT system framework and categorized into three main sub-indexes of development, implementation, and adoption. The following three tables in 〈Appendix 1〉, 〈Appendix 2〉, and 〈Appendix 3〉 summarize the variables and sub-variables used for CMPI. With these 30 variables, the CMPI is created to measure cryptocurrency potential not only in terms of usefulness but potential to be developed, implemented, and adopted.

Now that the sub-index with its variables and sub-variables have been determined, the relationship between each variables and sub-variables must be considered in terms of the DLT system framework so that their strength in describing the potential of blockchain-backed cryptocurrency can be examined. To do this, factor analysis is employed to describe the degree to which they are related and to determine the weights to use for each variable

for the CMPI.[4)]

Factor analysis allows for a breakdown of variables into an unobserved common factor component, namely the component that can provide insight into cryptocurrency's development, implementation, and adaptation. Furthermore, the factor loading for each variable used in the index correlates to the underlying component that provides insight into cryptocurrency potential. To determine how many factors will be used, both the "Kaiser criterion" and the "variance explained criteria" will help in determining significance. Factors with an eigenvalue of greater than 1 and with more than 80% of the variance is explained by the model will be used for this paper.

The process applying the factor analysis is as follows. First, raw data was gathered for the 213 countries and each country was ranked in according to the raw data for that variable to standardize the data set. In the end each country was ranked from 1 to 213 for each variable. The smaller the nominal value (closer to 1) the country was in that variable, the higher it's potential for cryptocurrency in terms of that variable. The standardized data then had factor analysis performed on it using the R program. When this was done, the uniqueness of each variable was given the factor loading of each variable as well as the SS loadings with factor weights via proportional variance, which provided for how much of the factors could explain the variance in the model. Performing factor analysis on the initial run, it was found that about a third of the variables have uniqueness that was over 0.20, indicating they might be unrelated to the model and potentially cryptocurrency while creating noise and error.

Hence factor analysis was redone with 21 variables which yield results that fit the Kaiser criterion and variance explained criteria. When factor analysis was done through R, the following results in the 〈Table 2〉 are obtained.

Using the 80% variance explained threshold, while considering the three main sub-indexes: development, implementation, and adoption, three factors are used for calculating the factor scores of the 21 final variables. The factor scores are calculated by the factor weight and factor loading obtained from the factor analysis. Additionally, the number of sub-variables under each variable are used to arrive at the factor scores. 〈Table 2〉 displays the factor scores that are used for the 21 final variables and sub-variables to weight for the CMPI.

Factor analysis yielded factor loadings which are the correlation coefficients between the variable and the factor in relation to cryptocurrency potential in this research. It is not the case where the factor loading can be simply inputted as the coefficient without looking at the factors involved and the variables correlating to each factor.

4) The BMPI used equal weights for variables and sub-variables to correspond to a major sub-index. This was done seemingly arbitrarily with the author's expertise and knowledge about the Bitcoin. On the other hand, the BRI used cosine similarity to compare each country's data to that of a "nonexistent, ideal" country. According to the OECD (2008), factor analysis provides strengths of being able to summarize a set of individual indicators while maintaining the maximum possible proportion of total variation in original data set. The largest loading factors will be assigned to indicators with largest variation across countries, which are desirable for cross-country comparisons.

〈표 2〉 CMPI를 위한 요인분석 점수
〈Table 2〉 Factor Scores for the CMPI

Variable Name	Variable Category	Corresponding Factor	Factor Weight	Factor Loading	Factor Score
BC	Sub-variable (.5)	2	.324	.82	.133
BCC	Sub-variable (.5)	1	.429	.907	.195
ET	Sub-variable (.5)	2	.324	.827	.134
ETC	Sub-variable (.5)	2	.324	-.912	-.148
HL	Sub-variable (.5)	2	.324	.855	.139
HLC	Sub-variable (.5)	1	.429	.874	.187
SL	Sub-variable (.5)	2	.324	.826	.133
SLC	Sub-variable (.5)	1	.429	.874	.187
II	Sub-variable (.3)	1	.429	.826	.118
IO	Sub-variable (.3)	1	.429	.767	.110
CO	Sub-variable (.3)	1	.429	.849	.121
IU	Sub-variable (.5)	1	.429	.929	.199
BR	Sub-variable (.5)	1	.429	.917	.197
BT	Sub-variable (.5)	1	.429	.579	.124
BTC	Sub-variable (.5)	1	.429	.786	.167
EN	Sub-variable (.5)	2	.324	.590	.096
ENC	Sub-variable (.5)	1	.429	.708	.152
RP	Sub-variable (.5)	3	.07	.916	.032
RA	Sub-variable (.5)	3	.07	.631	.022
BD	Variable	2	.324	.71	.23
ED	Variable	2	.324	.848	.274

Hence a factor weight had to be determined to appropriately incorporate the factor loading to determine its true weight in cryptocurrency potential. To do this firstly, the number of sub-variables had to be taken into account. For example, bitcoin development had two subvariables, Bitcoin developers per country and Bitcoin developers per capita, giving each sub-variables a weight of 0.50, variables that had three sub-variables would have a weight of 0.33. This was multiplied by the factor weight and factor analysis given by factor analysis to arrive at the factor score as shown in 〈Table 2〉. The "20" was added to avoid negative numbers when calculated CMPI scores in terms of each sub-index, and had no effect on the index itself in terms of where each country's ranking was relative to one another. The formula for calculating the score for each country in the CMPI is described as below for n = 1 to 213 countries with j = 1 to 21 variables:

$$CMPI\ Score = 20 + \sum_{i=1}^{n} Variable\ Weight\ \left(\frac{1}{\#\ of\ sub-variable}\right) \cdot Factor\ Weight \cdot Factor\ Load\text{-}X_{ij}$$

Ⅴ. Results

CMPI aims to measure not only usefulness and need, but also the existing infrastructure in terms of protocol development and a network that could implement cryptocurrency, and hence measures all three aspects: development, implementation, and adoption. The top 30 countries of the CMPI and their scores are shown in 〈Table 3〉.[5)]

The CMPI results coincide with real-world conditions where blockchain-backed cryptocurrency is being developed, implemented, and adopted with participants downloading the software for a cryptocurrency wallet and validating financial transaction as nodes. This is the case with Bitcoin where data is available due to its number of users, market capitalization, nodes, and downloads can be tracked.[6)]

Keeping the DLT system framework in mind, it is easy to understand the concentration of the top countries and their regional distribution in Europe and North America with certain well-known hotspots in Asia. Looking at the variables alone, there are a large number of developers that are not based where cryptocurrency can help people going through financial hardships and that would have benefitted the most from blockchain-backed cryptocurrency's advantages of decentralization,

〈표 3〉 CMPI 상위 30개 국가
〈Table 3〉 Top 30 Countries of the CMPI

Rank	Country	Score	Rank	Country	Score
1	Netherlands	23.048	16	Finland	85.904
2	Singapore	26.89	17	Italy	88.743
3	United States	27.398	18	Poland	91.15
4	United Kingdom	29.58	19	Israel	93.12
5	Canada	32.217	20	Austria	94.48
6	Germany	32.605	21	Taiwan	98.131
7	Switzerland	36.425	22	Norway	98.598
8	France	37.633	23	United Arab Emirates (UAE)	99.709
9	Australia	50.259	24	Japan	100.383
10	South Korea	65.56	25	New Zealand	103.234
11	Spain	66.269	26	Russia	108.548
12	Sweden	70.625	27	Czech Republic	108.731
13	Belgium	72.472	28	Luxembourg	117.801
14	Ireland	77.663	29	Ukraine	117.918
15	Denmark	82.58	30	Bulgaria	119.429

5) Refer to 〈Appendix 4〉 for the CMPI of 213 countries.
6) Refer to Bitnodes (2019) and SourceForge (2019) for details. It is easy to see the concentration of nodes mainly in Europe and the US, with hotspots in the Asia-Pacific region, the Middle East, CIS countries, and some southern parts of Latin America. Similarly, the download of Bitcoin software also displays concentration in large countries by absolute numbers and particularly Europe and North America lead as a region. This coincides with the CMPI constructed from thinking of the development, implementation, and adoption of cryptocurrency.

〈표 4〉 개발, 실행, 확산 하위지표의 상위 10개 국가
〈Table 4〉 Top 10 Countries for each Sub-Index: Development, Implementation, and Adoption

Development		Implementation		Adoption	
1. United States	2.593	1. Netherlands	25.819	1. Kosovo	22.262
2. United Kingdom	3.583	2. Singapore	27.691	2. South Sudan	22.568
3. Canada	5.9	3. Germany	29.614	3. Tuvalu	24.774
4. Netherlands	6.139	4. Switzerland	30.805	4. Curacao	24.944
5. Switzerland	7.364	5. Finland	31.299	5. Guinea-Bissau	24.976
6. Singapore	8.805	6. Hong Kong SAR	33.788	6. Dominica	24.994
7. France	13.575	7. France	34.94	7. China	26.298
8. Australia	15.791	8. Canada	35.231	8. Germany	26.706
9. Germany	16.285	9. South Korea	35.972	9. United States	26.726
10. Spain	18.429	10. Norway	36.77	10. India	26.982

transparency, and immutability. Those countries that may have corrupt or unstable governments and central banks unfortunately tend to have processes in place that makes it hard for cryptocurrency to be firstly developed and even more so to be implemented there. A large amount of existing capital may be needed to develop the ecosystem as evidence by the strong correlation between competitiveness, innovation, and the number of blockchain developers from looking at Factor 1 for development. Furthermore, strong and central governments may be less likely to allow their civilians to use global cryptocurrencies, such as that of France or Germany (AFP and Reuters, 2019).

The top five countries in the CMPI are the Netherlands, Singapore, United States, United Kingdom, and Canada respectively. In terms of their development, the number of absolute developers for blockchain and its application in each country were very high. The Netherlands and Singapore are higher in ranking when looking at it per capita. This is in line with each country's competitiveness as well where the Singapore was number one, US two, Netherlands four, Germany seven, and United Kingdom nine. Here size and population of the country did not necessarily give it an advantage for cryptocurrency potential, as smaller countries like the Netherlands and Singapore are high up in the ranking and beat traditionally competitive financial counterparts like Switzerland and Germany. These are countries with very high GDP per capita and it seems that blockchain development and implementation is highly correlated with countries having the financial capital and human resources to develop blockchain and possessing the technical know-how to implement blockchain-backed cryptocurrency. This is plausible as the DLT system framework highlights how important protocol and implementation is before the data layer so that consequent financial

transaction can take place. 〈Table 4〉 provides a further breakdown the CMPI by each sub-index.

Examining the top 10 countries in each sub-index supports the notion of blockchain development and implementation being concentrated in countries with high GDP per capita in Europe, North America, and Northeast Asia. This is evident with the US, Canada, European countries, and Singapore being in the top 10 for the development sub-index, whereas the implementation sub-index is similar with the addition of Hong Kong SAR and South Korea besides the European and North American countries. This is in contrast to the adoption sub-index, where looking at the top 10 alone, the configuration of countries is vastly different with small-island Pacific nations, South Sudan, and Kosovo constituting the top five for adoption. This is most likely due to their how heavily reliant their economies are on remittances, while major countries like China, Germany, US, and India round off the top ten for adoption to the numbers of Bitcoin and Ethereum software downloads.

Interestingly, those countries that rank high on variables involving development and implementation rank low on variables that deal with adoption. For variables such as inflation, financial crises, repression, and remittances these countries rank very low, yet rank high in interest in Bitcoin and Ethereum. This can be interpreted as cryptocurrency is not just only for those for financial need against traditional finance, but can also complement those in high GDP with stronger economies. Hence the advantages of transparency, immutability, and decentralization can not only help those in countries with corrupt and unstable governments but are also innovative enough to potentially better populations living in stable financial environments. This implies that although literature and research has thus far largely focused on helping those in less developed countries who can benefit from financial inclusion, the advantages of cryptocurrencies can also work to innovative finance in developed countries. Furthermore, these results show that although cryptocurrency is versatile in who adopts and benefits from it, it is not so versatile with who develops and implements it as seen with the high rankings of the top five in the development and implementation sub-index.

Ⅵ. Concluding Remarks

This paper, using CMPI, sought to answer if cryptocurrency would change the financial landscape and if countries could be ranked by their potential to incorporate this change through development, implementation, and adoption of blockchain-backed cryptocurrency. The CMPI constructed with the DLT system framework in mind used factor analysis to measure cryptocurrency potential with 30 variables. This was done to provide an index that looked at multiple aspects of blockchain-backed cryptocurrency to better and more accurately measure market potential of this new currency.

The CMPI analyzed cryptocurrency potential as a whole with a robust framework and a statistical approach. It's significance and usefulness are that it uses the DLT system framework to create an index that can be applied to not only just Bitcoin, but Ethereum and potentially Ripple

and other up-and-coming cryptocurrency since the DLT system framework is potentially applicable to these cryptocurrencies as well. By using this robust framework and using factor analysis to determine the weights of the variables and sub-variables in the index instead of arbitrarily assigning weights, the CMPI can be argued to be more effective than the current indexes that examine the potential of blockchain-backed cryptocurrency such as the BMPI and the BRI. The implications from the CMPI are that although cryptocurrency is often touted as a great tool for financial inclusion in the developing world, to truly achieve these missions, partnership between those that drive the development and implementation of cryptocurrency must be matched with those who are in needed of adoption for it as well. This has further implications for developers and businesses as they partner with governments and nonprofits to realize the mission of financial inclusion or for widespread usage of blockchain-backed cryptocurrency.

The results show that despite the decentralized nature of blockchain, the development itself and where blockchain could be widely used and implemented, are still consolidated around Europe, North America, a number of competitive countries in Asia, Middle Eastern, and CIS regions. The top countries in the CMPI are ones with very high GDP per capita. It proves that blockchain development and implementation is highly correlated with countries not only having the financial capital and human resources to develop blockchain but also possessing the technical know-how to implement blockchain-backed cryptocurrency. This result shows how important development and implementation is before adoption so that consequent financial transactions can take place. Furthermore, the results from the CMPI confirm that blockchain-based cryptocurrency as a whole could be developed and widely implemented so that it can be adopted. The results also show that cryptocurrency development, implementation, and usage are still not yet global. Although other countries could benefit more through positive social impact and financial inclusion with lower costs and more access, the results indicated there might be some difficulties in doing so considering the protocol and networks, along with the infrastructure and capital required to build and maintain them. This most likely would be a large obstacle for less developed countries to truly enjoy the benefits of cryptocurrency.

Furthermore, most research focused on the benefits of cryptocurrency for the impoverished and those with needs for a better financial system. Yet the results from the CMPI showed that those with a superior and stable financial system could adopt the benefits of blockchain-backed cryptocurrency as well. Hence adoption should not only be focused on impoverished regions but should be focused on how to innovative and best utilize the advantages of transparency, immutability, and decentralized in the advanced and developed economies as well.

The CMPI can be a great tool for policy makers and other entities looking to improve financial and currency landscape in their countries through cryptocurrency. Based on the analysis of the CMPI, it is recommended that the

technical components that affects development, implementation, and adoption should be considered as a whole when governments act to promote blockchain-backed cryptocurrency and that it can be both beneficial to those with financial need and those in developed economies looking for innovation in the finance industry.

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[Appendix]

〈첨부 1〉 CMPI의 발전측면 변수
〈Appendix 1〉 Development Variables for the CMPI

Variable	Full Name	Main Variable	Description	Source
1. BC	Blockchain Developers	Existing Developers	The number of blockchain developers per country	Dappros
2. BCC	Blockchain Developers	Existing Developers	blockchain developers per population (100,000 persons)	Dappros/ World Bank
3. ET	Ethereum Developers	Existing Developers	The number of Ethereum developers per country	Dappros
4. ETC	Ethereum Developers per Capita	Existing Developers	Ethereum developers per population (100,000 persons)	Dappros/ World Bank
5. HL	Hyperledger Developers	Existing Developers	The number of hyperledger developers per country	Dappros
6. HLC	Hyperledger Developers per Capita	Existing Developers	Hyperledger developers per population (100,000 persons)	Dappros/ World Bank
7. SL	Solidity Developers	Existing Developers	The number of Solidity developers per country	Dappros
8. SLC	Solidity Developers per Capita	Existing Developers	Solidity developers per population (100,000 persons)	Dappros/ World Bank
9. II	Innovativeness: Inputs	Potential to Develop	Captures elements of national economy that enable innovative activities	World Intellectual Property Organization
10. IO	Innovativeness: Outputs	Potential to Develop	Capture evidence of actual innovation outputs: knowledge and technology outputs, and creative outputs	World Intellectual Property Organization
11. CO	Competitiveness	Potential to Develop	4 composite indicators that measure attributes and qualities of national economies to efficiently use factors of productions	World Economic Forum (WEF)

〈첨부 2〉 CMPI의 실행측면 변수
〈Appendix 2〉 Implementation Variables for the CMPI

Variable	Full Name	Main Variable	Description	Source
1. MO	Mobile Subscriptions	Technology Penetration	Mobile subscription per 100 people	World Bank, citing International Telecommunication Union, World Telecommunication/ICT Development Report and database.
2. IU	Internet Usage	Technology Penetration	Percentage of population with internet access	World Bank, citing International Telecommunication Union, World Telecommunication/ICT Development Report and database.
3. BR	Broadband Usage	Technology Penetration	Broadband subscription per 100 people	World Bank, citing International Telecommunication Union, World Telecommunication/ICT Development Report and database.
4. BT	Bitcoin Nodes	Bitcoin Penetration	Number of Bitcoin Nodes	Bitnodes
5. BTC	Bitcoin Nodes per Capita	Bitcoin Penetration	Number of Bitcoin nodes per 100,000 of the population	Bitnodes/ World Bank
6. EN	Ethereum Nodes	Ethereum Penetration	Number of Ethereum Nodes	Ethernodes
7. ENC	Ethereum Nodes per Capita	Ethereum Penetration	Number of Ethereum nodes per 100,000 of the population	Ethernodes/ World Bank
8. LS	Legal Status	Legal Status	Absolute Ban: -2, Implicit Ban: -1, No Ban: 0; Tax Law:+1, Anti-money laundering:+1, Anti-terrorism financing law: +1; Own cryptocurrency:1. Score added up and ranked.	Law Library of Congress

〈첨부 3〉 CMPI의 확산측면 변수
〈Appendix 3〉 Adoption Variables for the CMPI

	Full Name	Main Variable	Description	Source
1. IF	Inflation	Inflation	Average of annual inflation rates from 2009-2018	World Bank, citing International Monetary Fund, International Financial Statistics and data files.
2. RP	Remittances, Percentage	Remittances	Remittances amount received as percentage of GDP	World Bank, citing IMF balance of payments data, and World Bank and OECD GDP estimates.
3. RA	Remittances, Amount	Remittances	Amount of remittances received by the country	World Bank, citing IMF
4. BM	Black Market	Black Market	Taken from BMPI	Hileman 2015
5. FC	Financial Crises	Financial Crises	Taken from BMPI	Hileman 2015
6. FR	Financial Repression	Financial Repression	Taken from BMPI	Hileman 2015
7. EF	Economic Freedom	Economic Freedom	Economic Freedom Summary Index Ranking each country	Fraser Institute
8. BD	Bitcoin Software Download	Bitcoin Interest	Number of Bitcoin Software Downloads from 2008-11-09 to 2019-11-01	SourceForge.Net
9. BS	Bitcoin Search Term	Bitcoin Interest	Google search for Bitcoin (currency) from a scale of 0-100 based on number of searches over total searches	Google Trends
10. ED	Ethereum Software Download	Ethereum Interest	Number of Ethereum Software Downloads from 2016-12-16 to 2019-11-11	SourceForge.Net
11. ES	Ethereum Search Term	Ethereum Interest	Google search for Ethereum (currency) from a scale of 0-100 based on number of searches over total searches	Google Trends

〈첨부 4〉 213개 국가의 CMPI
〈Appendix 4〉 The CMPI of 213 Countries

Ranking	Country	Score
1	Netherlands	23.048
2	Singapore	26.89
3	United States	27.398
4	United Kingdom	29.58
5	Canada	32.217
6	Germany	32.605
7	Switzerland	36.425
8	France	37.633
9	Australia	50.259
10	South Korea	65.56
11	Spain	66.269
12	Sweden	70.625
13	Belgium	72.472
14	Ireland	77.663
15	Denmark	82.58
16	Finland	85.904
17	Italy	88.743
18	Poland	91.15
19	Israel	93.12
20	Austria	94.48
21	Taiwan	98.131
22	Norway	98.598
23	United Arab Emirates (UAE)	99.709
24	Japan	100.383
25	New Zealand	103.234
26	Russia	108.548
27	Czech Republic	108.731
28	Luxembourg	117.801
29	Ukraine	117.918
30	Bulgaria	119.429
31	Portugal	120.427
32	Slovenia	120.867
33	Malaysia	125.405
34	Hungary	126.27

Ranking	Country	Score
35	Romania	127.136
36	China	127.258
37	Belarus	133.059
38	Estonia	134.232
39	Brazil	134.315
40	Latvia	138.959
41	Croatia	141.902
42	Slovakia	144.555
43	Hong Kong SAR	144.956
44	Kosovo	146.904
45	Greece	148.072
46	Turkey	151.102
47	Thailand	152.495
48	Serbia	152.515
49	India	152.626
50	Curacao	152.71
51	Cyprus	157.615
52	Lithuania	159.686
53	South Africa	161.762
54	Vietnam	166.053
55	Malta	167.065
56	Bermuda	168.102
57	Gibraltar	172.792
58	Mexico	173.936
59	Monaco	179.065
60	Chile	179.514
61	Philippines	187.691
62	Andorra	189.627
63	Puerto Rico	190.025
64	Saudi Arabia	192.208
65	Turks and Caicos	200.945
66	Venezuela	201.607
67	Colombia	201.813
68	Sint Marteen	204.804

Ranking	Country	Score
69	Argentina	205.364
70	Iceland	206.415
71	Tunisia	206.725
72	Virgin Islands (US)	206.767
73	Liechtenstein	207.337
74	New Caledonia	208.501
75	Kazakhstan	211.106
76	Indonesia	212.544
77	Costa Rica	212.566
78	Macao SAR	213.653
79	North Macedonia	214.43
80	Cayman Islands	214.939
81	Iran	215.364
82	Moldova	216.055
83	Bahrain	216.271
84	Uruguay	218.472
85	Qatar	219.697
86	Faroe Islands	219.727
87	Peru	220.32
88	British Virgin islands	221.15
89	Pakistan	222.928
90	Bosnia and Herzegovina	225.121
91	Greenland	225.646
92	Georgia	228.875
93	Lebanon	229.096
94	Barbados	229.322
95	Egypt	231.17
96	Morocco	233.025
97	Nigeria	237.987
98	Nauru	239.775
99	Dominica	239.992
100	Dominican Republic	241.919
101	Armenia	242.757
102	Jordan	245.388
103	Kenya	248.583
104	French Polynesia	250.199

Ranking	Country	Score
105	Panama	251.395
106	Albania	252.363
107	Sri Lanka	252.496
108	Guam	252.496
109	Uzbekistan	255.698
110	Belize	256.147
111	Tuvalu	256.498
112	Kuwait	259.361
113	Aruba	260.501
114	Azerbaijan	262.779
115	Bangladesh	264.942
116	Bahamas	266.108
117	Mauritius	266.365
118	San Marino	266.668
119	Algeria	268.802
120	Suriname	272.478
121	Congo, Rep.	272.608
122	Ecuador	273.68
123	Palestine	273.849
124	North Korea	273.915
125	Montenegro	274.816
126	South Sudan	276.215
127	Eritrea	276.343
128	Oman	278.139
129	Eswatini	278.394
130	Guinea-Bissau	283.889
131	Sudan	284.245
132	Nepal	284.299
133	Saint Vincent and the Grenadines	284.516
134	Grenada	284.73
135	Ghana	284.963
136	Saint Lucia	288.072
137	Palau	288.079
138	Angola	290.969
139	Saint Kitts and Nevis	291.145
140	Bolivia	294.567

Ranking	Country	Score
141	Afghanistan	294.667
142	Trinidad and Tobago	295.823
143	Jamaica	297.28
144	Bhutan	297.466
145	Honduras	297.724
146	Myanmar	298.161
147	Cape Verde	300.97
148	Mongolia	303.699
149	Brunei	304.111
150	Tonga	306.519
151	Syria	308.202
152	Guatemala	308.791
153	Maldives	308.921
154	Cuba	309.291
155	Papua New Guinea	310.397
156	Paraguay	311.084
157	Cambodia	311.246
158	Fiji	311.513
159	Iraq	311.934
160	Nicaragua	311.954
161	Equatorial Guinea	312.803
162	Tanzania	314.058
163	Senegal	314.291
164	Mauritania	315.813
165	Antigua and Barbuda	315.907
166	Micronesia	316.622
167	Samoa	316.966
168	Marshall Islands	317.217
169	Sao Tome and Principe	317.75
170	Vanuatu	320.316
171	Libya	320.602
172	Turkmenistan	320.607
173	Liberia	320.614
174	Cote d'Ivoire	321.144
175	El Salvador	323.005
176	Uganda	323.062
177	Kyrgyzstan	324.114

Ranking	Country	Score
178	Seychelles	324.458
179	Zimbabwe	325.332
180	Togo	325.342
181	Timor-Leste	325.825
182	Laos	327.873
183	Guyana	328.118
184	Kiribati	328.496
185	Central African Republic (CAR)	329.649
186	Gambia	330.371
187	Comoros	330.407
188	Sierra Leone	330.538
189	Tajikistan	332.409
190	Chad	336.177
191	Zambia	336.196
192	Ethiopia	339.259
193	Cameroon	340.206
194	Botswana	340.707
195	Lesotho	342.367
196	Somalia	348.865
197	Rwanda	354.731
198	Djibouti	356.127
199	Gabon	357.489
200	Yemen	358.834
201	Benin	358.859
202	Guinea	359.494
203	Namibia	368.325
204	Congo, Dem. Rep.	368.61
205	Solomon Islands	369.141
206	Madagascar	375.047
207	Mozambique	378.283
208	Haiti	381.58
209	Burkina Faso	384.026
210	Mali	386.512
211	Niger	394.235
212	Malawi	395.074
213	Burundi	398.163