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An Algorithmic Blockchain Readiness Index †

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Abstract: This paper presents the design of a Blockchain Readiness Index (BRI) to be used as a tool for assisting nations to monitor the level of Blockchain maturity according to their suitability on hosting blockchain-based activities, and successfully adopting a blockchain regulatory framework. BRI is a composite index that combines a variety of indicators from a range of sources to a single score. The proposed methodology attempts to fill a knowledge gap by evaluating the relatively unexplored area of blockchain adoption per nation. The index presented in this paper aims to distinguish between the most promising and non-hostile countries, acting as the basis for professional work, decision making and operations of organizations, investors, academics, and other stakeholders within the blockchain space. As the index is updated regularly, all new developments on the fast-changing landscape of blockchain and cryptocurrencies are reflected. In addition, this research aims to go beyond the regulatory environment towards examining several other factors such as local engagement, expertise, investments, and the need for a decentralized provision of services. This paper presents an overview of the landscape of similar attempts on designing such indexes by reviewing and identifying potential gaps and opportunities for improving their methodological design that can lead to more accurate and relevant conclusions. In addition, with this paper we contribute a systematic methodology for building a BRI using techniques from the information retrieval domain to normalize the non-normalized values, and a cosine similarity measure to derive an index ranking consisting of various nations. More specifically the proposed BRI covers a wide range of blockchain readiness indicators which can be organized into the following "pillars": (1) Government Regulation, (2) Research, (3) Technology, (4) Industry, and (5) User Engagement. An empirical evaluation reports preliminary but promising results of the algorithmic design methodology showing evidence that, the identified indicators are sufficient for developing our index when compared to judgements made by human experts.

Keywords: Blockchain Readiness Index; indicators; Blockchain Regulation; Blockchain technology; user engagement; public interest; Blockchain Adoption; decision making

1. Introduction

The rapid growth of Distributed Ledger Technologies with the realization of Blockchains, leading the forefront of this technology, has been disrupting a plethora of human activities ranging from a new economy of money, social interactions, business-to-business interchange, legislation, the public sector and many more. With this evolution of human activities led by Blockchain technology, it is hard to monitor how different countries are reacting to this change. Under this new state of affairs many nations are faced with the challenge of catching up with the trend and harness this technological innovation while at the same time seeking a balance, by mitigating potential risks that are likely to arise, from the consequences of applying a premature, emerging technology.

The main aim of Readiness indexes is to provide a single numerical representation of how engaged an examined item is - such as a nation, region or entity - towards a specific subject or sector. There are quite a few paradigms of readiness indexes constructed to evaluate technological innovations, some of which are described in Section 2.1.3 of this paper. The reader is referred to Section 3 for a systematic review. The proposed BRI is constructed with the purpose of identifying non-hostile nations where blockchain-based conditions can enable businesses and investors to operate, thereby reducing the business and financial risk of stakeholders. Several factors are examined and weighted accordingly, through extensive research and surveys from the industry's insights. Opinions and statistics from governmental authorities, blockchain startups and existing use cases can also be taken into consideration.

Major financial and technological institutions consider Blockchain technology a breakthrough concept. Consortiums like R3 (https://www.r3.com/) and Hyperledger (https://www.hyperledger.org/) have been formed with the aim to transform business operations and encourage worldwide adoption of the technology as internal and/or external part of business processes. These consortiums bring together the most prominent financial and technological organizations in the world such as Barclays, BBVA, Citi, Wells Fargo, Accenture, IBM and others. With major institutions, from a wide spectrum of domains, leading the way of adoption, it is without a doubt that Blockchain technology is widely regarded as disrupting and promising [1]. Although we are experiencing a diversification in utilizing the technology, in reality the technology has yet to become a game-changer to traditional procedure and business models. This is mainly because industry stakeholders experience a lack of Blockchain technology awareness and/or operate under a grey regulatory area, which often leads to poor or immature decision making.

There is a general belief that Blockchain technology revolution will accelerate identically to the rate followed by the evolution of the World Wide Web during the 1990s. The decentralized nature and implementation complexity of Blockchain technology solutions may indicate that, the road to wide adoption is not as smooth as in the case of the World Wide Web. However, blockchain-driven disruption will probably affect the society more significantly (or at least similarly) than the Internet, as the main use cases seem to involve the treatment of digital money and assets.

An ongoing study published by CryptoFUNDResearch [2] demonstrated that an increasing number of crypto-funds launched, including hedge funds and venture capitals. By June 2018, Digital Currency Group, Pantera Capital, and Blockchain Capital were the top 3 venture capital investors with $78 million, $65 million and $71 million value of investment respectively [2]. Since then, there was a steady grow of crypto assets under management with the most updated metrics (April 2019) indicating a total figure exceeding $14 billion. The CryptoFUNDResearch [2] indicates that many crypto-funds have now exceeded $100 million in assets including Pantera Capital, Galaxy Digital Assets, Alhpabit Fund, and Polychain Capital. The value of investments by the top 50 venture capital blockchain firms is proportionally increasing by year, as the total investment value of $496.7 million in 2017, has been surpassed in 2018 with $637.7 million raised up to June 15, 2018. The majority of these investments (79.8%) used to fund Blockchain companies through seed, and early stage funding rounds. Furthermore, Initial Coin Offerings (ICOs) attracted a significant portion of this investment (14.7%). Overall, the majority of such investments were located in startups operating in the United States, while a few of them were based in Hong-Kong, with a smaller portion reported from investments made in central Europe [2].

In 2018, 239 crypto fund launches were initiated. Almost half of crypto fund launches were located in USA, the United Kingdom, China/Hong Kong, Singapore, Switzerland, Canada, Australia, and Germany all experienced a noteworthy launch of crypto-funds, while regions in Eastern Europe, offshore jurisdictions, and Russia were also experiencing an increased activity.

There are hundreds of other initiatives worldwide initiating a huge flow of funding without a noteworthy implementation to date. The current issue is that the majority of these funds seem to be invested towards projects without a clear, promising vision due to the nature of the project itself, or due to the market and region that is meant to be applicable to. At least 80% of ICOs conducted in 2017 have been identified as "scams" according to a study published by the Statis Group [3].

1.2. Summary of Contributions

According to Kakavand et al. [4] the cryptocurrency and blockchain industry is emerging, however, we are still in the early adopters' phase [5]. Consequently, there is a significant lack of knowledge on several research areas, including the aspects of technology, regulation and community engagement. The motivation of the proposed index is to identify the scale of blockchain related operations worldwide and demonstrate the suitability of regions on hosting blockchain-based activities and successfully adopting a blockchain regulatory framework, whose importance is highlighted by Yeoh [6], which will pursue their position as a global blockchain hub. The index is of a dynamic character, as the components of this index are updated regularly to reflect all the new developments in the space. The following observations motivated this study.

- There is a lack of Blockchain knowledge in startups and/or individual investors on their decision-making with regards of which nations are blockchain-friendly to host their operations, and establish collaborations.
- Governmental authorities often fail to identify the most enabling conditions on deciding which actions need to be taken, in order to position their nation as a blockchain hub. Nations with a low score on specific indicators may use the results to initiate developments, which will exploit any areas of improvement.

In seeking answers to the aforementioned observations, the proposed Blockchain index aims to exhibit the following contributions: (i) an overview of the landscape of published indexes that focus on Blockchain and cryptocurrencies, and (ii) a systematic methodology for deriving a single score that characterizes the level of preparedness of nations for Blockchain technology.

The proposed BRI is expected to influence various stakeholders from the industry by enabling them to exploit the numerical scores for each individual measure (i.e., indicator) to further improve their perspective in a specific country with respect to the development of Blockchain technologies. In addition, it is expected that our index provides an overview to the enabling environment of the technology that is affected by the following dimensions:

- ***Socioeconomics.*** An analysis of how and to what extent local societies progress, after specific economic activities and/or operations take place [7].
- ***Legal management.*** An evaluation of the regulatory landscape of the assessed nations.
- ***Political economy.*** An examination of the relationship of blockchain production/output per nation with local government practices, and distribution of income [8].
- ***Managerial economics.*** An assessment of the challenges an organization and/or society is likely to face that affect decision making procedures [9].

2. Related Work

Blockchain technology [10] is still a nascent field becoming a promising technology for the next generation of future internet systems, and applications. Despite the fact that Blockchain is expected to impact the Internet with enabling decentralized transactions, smart contracts, virtual nations, and used as a driver for other emerging technologies (e.g., Artificial Intelligence), the treatment of the technology has proved challenging for nations worldwide. Up to this date, legislation and rules for using the technology and treating crypto-assets is varying by nation or even do not exist. Similarly, the industry is emerging at varying degrees of technological maturity within each region. Local blockchain engagement and research advancement differs per nation while startups are considering several nations to operate.

2.1. Overview of Current Status

Only a handful of nations have attempted to create a blockchain-focused regulatory framework (such as Malta and Gibraltar) or have clearly indicated how cryptocurrency and blockchain operations are treated [11]. Still each of these efforts, are focusing on different topics and do not cover all the essential legal areas. The lack of a cryptocurrency framework is likely to cause a confusion and

disputes between potential investors, businesses, end-users, and local authorities. From the other hand, the adoption of the technology to the use-case of cryptocurrencies shows the potential of what the technology can offer and therefore misuse of the technology to facilitate illegal financial activities should be unlinked from the technology itself. Indeed, blockchain is gaining traction for some nations that are recognizing its disruptive potential pushing governments to seek a balance between encouraging activities that promote the usage of the technology but at the same time provide regulatory treatments for cryptocurrencies, taxation, protecting investors, and preventing financial terrorism.

Blockchain related research is conducted mainly by developed nations but holds the potential to bridge the gap with developing countries or instance, Switzerland is seeking to become a "Crypto-Valley"; a hub for companies and start-ups that leverage on the technology, while interest to underdeveloped countries is increasing, currently focusing on potential solutions on the microfinance and remittance issues [12]. Although the technology has already shown its disruptive character, when it comes to regulation there is a lack of harmonization of the crypto-assets regulation between nations. Each country is treating them differently presenting their own strategy that fall across the spectrum of either encouraging the use of crypto-assets or exploiting the technology to completely forbidding them.

As a result, the level of blockchain technology awareness and investment varies among nations and it's driven by a variety of factors. Section 3, presents an overview of our methodology that considers such factors as the building blocks for the construction of the proposed BRI. The formation of the proposed BRI is expected to add value with regards to identifying the most promising enabling conditions for using and implementing the technology, as well as, to introduce a single metric that can facilitate a better understanding of how the technology is treated at the national level.

2.1.1. The "Blockchain and Cryptocurrencies Regulation Index 2018"

There is limited research done to date, as a means to construct an index which identifies crypto and blockchain friendly nations by consolidating various factors and dimensions that are likely to influence its adoption, user-friendliness, and encourage industries/businesses to use them. The "Blockchain and Cryptocurrencies Regulation Index 2018" presents a relevant study conducted to identify non-hostile nations on hosting blockchain related activities. This index evaluates three "dimensions" [13] (the equivalent of "pillars" of the study presented in this paper), as follows: (1) Legal Environment, (2) Political Environment, and (3) Infrastructure Environment.

In [13] the *Legal Environment* is assessed based on the degree to which the regulatory environment is enabling for the development of activities associated with blockchain and cryptocurrencies. In general, the study attempts to focus on the social and economic relations that are likely to affect the interest of stakeholders while using the technology. Their attempt is to assess the general legal environment on how it enables blockchain and cryptocurrency activities [13].

The impact of the rule of law on the general legal environment is calculated by multiplying the numerical value of each of the four criteria ("Regulatory convergence", "Definiteness of legal regulation", "Stability of legal regulation", "Adequacy of legal regulation") by the World Justice Project's (WJP) Rule of Law Index score for each specific country.

For the *Political Environment,* this is assessed by determining the positions of different entities (e.g., executives, representative authorities, courts, central banks, principal financial institutions, business associations and public associations with respect to the development of blockchain technologies in each country. The attitude from such positions is reflected using a binay scale (1: positive, 0: negative). Score "1" is assigned when there is definite emphasis, while score "0" is assigned when there is no emphasis. If the difference between the sums of average positive and average negative assessments is above "0", then the attitude is positive and vice versa.

Finally, the *Infrastructure Environment* for each country is assessed on a set of conditions that ensure the feasibility of blockchain-related project implementations (e.g., Internet penetration, broadband access, society digitalization, population's literacy etc.). For this dimension, these

conditions are based on two other established indexes i.e., The E-Government Development Index (EGDI), and the World Bank's Doing Business Index.

Even though the work presented in [13] is closely related with the presented in this paper, we point limitations that need to be addressed. Firstly, this index is mostly focused on the governmental/legal standpoint rather than also considering the technology aspect, the academia and the public interest. Our proposal is that all these factors must be taken into consideration and weighted accordingly by the index. Secondly, some indicators that involve the technology aspect are not directly related to the cryptocurrency and blockchain landscape e.g., internet literacy, mobile connectivity, expected years of schooling etc. In our view, the ideal BRI shall be based mainly on cryptocurrency and blockchain metrics e.g., mining activities, bitcoin ATMs, relevant research publications etc. It should be noted that, whenever possible, the weight of pillars and indicators towards the final rankings, should be based on a systematic algorithmic process rather than assumptions.

Furthermore, our view is that the "Blockchain Readiness Index" should evaluate a sufficient number of countries and economies around the world rather than only one African country (South Africa) and one Latin America country (Argentina) that are mainly assessed in the "Blockchain and Cryptocurrencies Regulation Index 2018" [13].

2.1.2. Blockchain Related Indexes

Other projects like the Global Cryptocurrency Benchmarking Study [14] displays blockchain related adoption among regions. However, this study is mostly indicating engagement of continents and wider regions rather than indicating blockchain engagement per country. Furthermore, the Global Cryptoasset Regulatory Landscape Study [15] attempts to present a comparative analysis between various jurisdictions, such as, Malta, Gibraltar, Bermuda, France, Abu Dhabi and more. However, similarly to the "Blockchain and Cryptocurrencies Regulation Index 2018", the aforementioned projects do not address the technology, academia, and public interest aspects but rather focus only on existing regulatory frameworks and guidelines.

2.1.3. Technology Related Indexes

There are several other indexes developed to measure technology related metrics. The "Networked Readiness Index" by the Global Information Technology Report [16], also known as "Technology Readiness", is a project maintained by the World Economic Forum and attempts to measure the propensity of nations to exploit the opportunities offered by Information and communications technology (ICT) developments. The 2016 edition of the "Networked Readiness Index" evaluated 139 nations, classified Singapore, Finland and Sweden as the top three countries. The objective of the research presented in this paper is to develop a similar composite index for measuring the level of preparedness of countries with regards to the Blockchain technology, focusing on regulation aspects, research capabilities, engagement of local cryptocurrency users etc.

Moreover, other indexes that aim to rank nations or regions with regards to their ability to become innovators on new technological advancements, include the "Autonomous Vehicles Readiness Index" [17], the "Automation Readiness Index" published by the Economist Intelligence Unit [18] and the "Smart Industry Readiness Index" published by the Singapore Economic Development Board [19]. A common denominator of these initiatives is the attempt to forecast potential outcomes derived from advancements on various sectors of the fourth industrial revolution.

In general, there is a vital research gap currently existing for Blockchain indexes. Thus the goal of this research is to bridge this gap by providing an index that systematically and algorithmically combines various factors per country (taking into account a wide range of information pillars) into a single score that can be used to provide insights with regards to the acceleration of the transformational social and economic benefits that the Blockchain technology could offer to society.

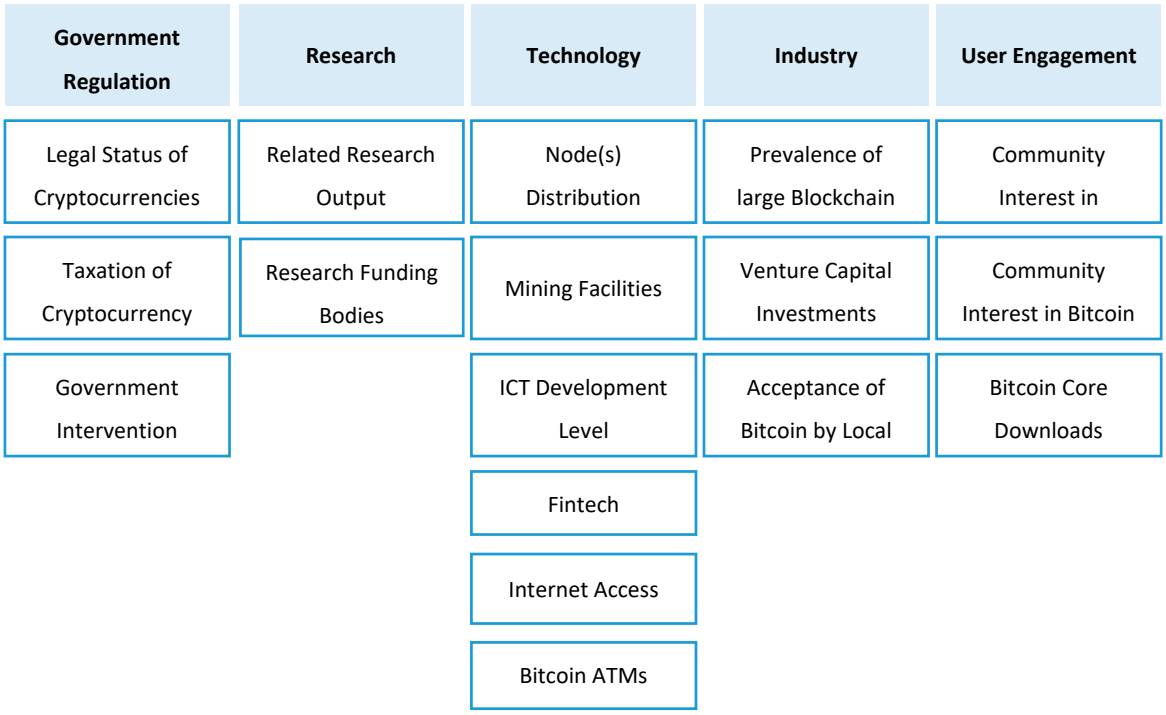

Figure 1. Indicators considered for the proposed Blockchain Readiness Index.

3. Proposed Methodology

In this section, a methodological framework is described that can be used for the development of the proposed BRI. In this context, several factors referred to as *indicators* are detailed, which constitute the building blocks of the proposed index. Figure 1 provides an overview of the indicators leveraged by the proposed BRI, that are categorized into groups called *enablers*. In subsequent sections we provide definitions for each.

3.1. Indicators

The "Blockchain Readiness Index" is constructed with the aim to add value in the industry and be able to influence decisions of external stakeholders. In order to achieve this goal, the ranking of each nation must be based upon reliable, relevant and updated indicators demonstrating a high level of data theory [20]. The indicators below have been identified as the major components of the index. Although, as elaborated in Section 4 any numerical value has the potential to be included as part of our index.

3.1.1. Government Regulation Indicators

In this enabler we seek to capture positive or negative signals with regards to the various governmental and regulatory conditions that are likely to influence a country's perspective to becoming a Blockchain hub for technology businesses, and attract financial activities.

(a) Legal Status of Cryptocurrencies

- ***Official recognition of cryptocurrencies:*** Cryptocurrencies are recognized differently among countries/regions. Most jurisdictions apply policies and rules, which are directly expressed for Bitcoin, while others refer to the treatment of cryptocurrencies in general by proposing a more general regulatory framework. Countries whose authorities have officially recognized Bitcoin or cryptocurrencies in general as financial instrument, property or commodity are favored.
- ***Prohibition of activities associated with cryptocurrencies:*** Various governmental bodies, and authorities have classified cryptocurrencies differently. In some countries, official authorities

have explicitly allowed its use and trade, but others have banned or restricted it. Such bans and restrictions provide a negative signal for the index.

- ***Legal status remains a grey area:*** There are countries, which did not yet announce how cryptocurrencies or activities that relate with cryptocurrencies should be treated. The legality in this area is still undefined and questionable while these countries generally focus to the risks of cryptocurrencies (e.g., issues with financial stability). However, if no established regulation on cryptocurrencies exists, the use of them is still not illegal. Countries where Bitcoin and cryptocurrencies are regulatory placed within a grey area experience a neutral impact on the rankings.

(b) Taxation of Cryptocurrency Income/Profits

Transacting and/or trading with cryptocurrencies may require tax liabilities for the users. Regulatory bodies such as IRS and the European Court of Justice have issued guidance on the treatment of Bitcoin and other cryptocurrencies. Mining can also be considered in some occasions as an immediate income. Countries with established tax guidance are credited positively.

(c) Government Intervention in Cryptocurrency activities

- ***Government measures to develop blockchain based strategies:*** Even though a limited number of nations have launched a blockchain/cryptocurrency regulatory framework, there are quite a few governmental authorities, which have created local taskforces and strategies, set to be implemented in the near future. Countries with an innovative character are credited positively in the proposed BRI.
- ***Government tight regulatory controls:*** Even in countries where cryptocurrencies are officially recognized and used by the public, tight regulations may still appear to slow down the growth of Blockchain startups. Such regulations may force exchanges to collect excess information to identify customers, impose additional trading fees, and acquire expensive licenses while in some cases the use of cryptocurrencies is even prohibited within some sectors. Our perspective is that countries with tight regulatory controls must be taken into consideration.

3.1.2. Research Indicators

In this enabler we seek to capture positive or negative signals with regards to the ongoing research efforts from the community into the demands for designing a DLT system. Efforts that are supported by governmental bodies or community efforts.

- ***Research funding bodies:*** This indicator considers countries that actively seeking to become friendly for Academic Institutions, start-ups, and other initiatives that work on the fundamentals of the technology. Especially, countries that are funding such initiatives for research and development are considered positively.
- ***Related research output***: The 100 most downloaded "Blockchain" related publications in SSRN eLibrary indicate engagement of authors and local research towards the concept. The area of residence and work of the authors is considered. This indicator is capturing data by using various keywords e.g., "Blockchain" to search for titles, abstracts and keywords in searching various academic libraries.

3.1.3. Technology Indicators

In this enabler we seek to capture positive or negative signals with regards to a country's contribution to the eco-system and the anatomy of the infrastructure and ICT literacy of the society.

- ***Node Distribution:*** The estimation of the size of Bitcoin is calculated by finding all the reachable nodes within different regions. Even though nodes running older versions of the protocol may be hard to locate, the calculated percentage of nodes in each country is expected to be reliable. Besides Bitcoin nodes, Ethereum nodes are located and shall be included as a

metric in the index, as these two decentralized networks are constantly the most widely used and developed networks since their Genesis block.

- ***Mining Facilities:*** This indicator considers statistics published by mining maps (as shown in [21]) that shows an estimate of the location of medium-to-large scale mining operations around the world. The origin of approximately half the bitcoin hash rate is captured, because some mining locations are kept secret.
- ***ICT Development Level:*** The ICT Development Index (IDI) is an index published by the United Nations International Telecommunication Union based on internationally agreed ICT indicators. Development on these areas indicates room for innovation towards Blockchain-specific activities. Iceland, Republic of Korea and Switzerland top these rankings.
- ***FinTech Engagement:*** FinTech ecosystem and infrastructure varies between countries. Demographics and the overall state of the economy are strongly related to FinTech engagement. The 2018 IFZ Global FinTech Rankings by The Institute for Financial Services Zug (IFZ) is a comprehensive research study identifying the regions with advanced FinTech ecosystems examining factors associated with driving entrepreneurship and innovation, as well as indicators related to financial technologies. As numerous entrepreneurs and start-ups are identified, Singapore and Switzerland are on the top of this list. We consider such data as an indicator to our BRI.
- ***Internet Access:*** Internet penetration rates indicate the likelihood of Blockchain adoption within regions. Internet users are defined as persons who accessed the internet in the last 12 months, from any device. According to World Bank Data (https://data.worldbank.org/), internet users are compared to the total population of a country to conclude on a certain percentage. This information may not directly be related to Blockchain adaptability but high internet penetration rate is still a positive sign, which shows room for development of the concept.
- ***Bitcoin ATMs launched:*** The number of Bitcoin ATMs serving the population. Bitcoin ATMs allow for an easy and convenient on-ramp into the Bitcoin ecosystem and installation rates indicate the rate at which a country or economy is accepting Bitcoin and how easy it is for the population to deposit and withdraw Bitcoin in exchange for cash. Data that relate to Bitcoin ATM installations are closely tracked by coinatmradar.com which our index considers.

3.1.4. Industry Indicators

In this enabler we seek to capture positive or negative signals with regards to the penetration of the technology to the industry and emerging businesses.

- ***Prevalence of large Blockchain startups:*** The number of large Bitcoin and Blockchain companies within each country is useful as an indicator to show the prevalence and the engagement within an economy of Bitcoin and Blockchain as an industry. It also provides a welcome environment to innovate without distraction from regulation and prosecution. The top 100 most influential Blockchain companies are considered, as published by Richtopia (https://richtopia.com/).
- ***Venture Capital Investments:*** The amount of investment inflows into a country through private equity. Indicates the willingness of investors to make capital investments in risky but high growth potential Bitcoin and Blockchain companies and the acceptance of governments to allow for innovation within their borders. Data provided by sources e.g., the Crypto Fund Research (https://cryptofundresearch.com/) on investments are considered and updated regularly.
- ***Acceptance of Bitcoin by local companies:*** The number of companies within a country that accept Bitcoin in exchange for payments of goods and services indicates the acceptance of Bitcoin as a legitimate form of currency alongside local currency, and the ease of access to the general population this provides. Such data, are considered and from sources e.g., Coinmap.org.

3.1.5. User Engagement Indicators

In this enabler we seek to capture positive or negative signals with regards to community efforts and user engagement per country.

- ***Community interest in Blockchain:*** The increase over time of the number of Web searches that include the term "Blockchain" indicates a trend within a country's interest to the Blockchain technology.
- ***Community interest in Bitcoin:*** Similarly, as above, the increase over time of the number of Web searches that include the term "Bitcoin". This indicates a trend within a country's interest to Bitcoin as a concept and as a cryptocurrency.
- ***Bitcoin Core downloads:*** The total number of Bitcoin Core downloads as derived from Sourceforge.net, indicates local engagement and interest, as well as, a rough estimate of where most Bitcoin users are located. The data date range considered is from 2008-11-09 to today.

3.2. Challenges

Since blockchain is an emerging and rapidly changing field [22], any kind of modification on the current list of indicator sources is possible. However, our view is that the nature of these indicators is not subject to major changes in the near future. These indicators are expected to remain relevant as far as their contribution in developing the BRI.

This paper has outlined the key indicators, which should be evaluated and included in the development of a BRI. To implement an actual report with final country rankings, careful consideration needs to be given to the weight of each indicator. There are certain indicators, which should contribute at a higher rate than other indicators of not high significance e.g., Legal Status of Cryptocurrencies vs Internet Access.

Research to obtain further results shall be focused on academic and industry journals while surveys and interviews can be conducted with people associated with the blockchain industry. Even though a combination of quantitative and qualitative methodology could assist towards an efficient data collection and analysis [23] the industry is currently at a primitive stage to safely determine if such a combination is feasible and ideal. These methods could serve as the main drivers of obtaining relevant information as the aim is to focus towards gathering data both from interviewing industry experts as well as from average cryptocurrency users worldwide. For our preliminary evaluation we used testimonies from human experts (refer to Section 4) as ground truth to our algorithmic approach.

We anticipate that for the purposes of our research we may lack enough source data to cover all indicators for all recognized nations (200+) but more are likely to be provided in the future. Our aim is to cover a carefully selected sample of nations based on the available data that are needed to feed our algorithmic approach. For selecting the sample we have chosen to covering a range of nations differing in size, blockchain engagement, technology advancement, GDP per capita etc. Three nations which differ in most of these aspects and are expected to be among the first use cases tested for this research, are the USA (expected on a top-tier ranking), Cyprus (expected on a medium-tier ranking) and Nigeria (expected on a low-tier ranking).

Finally, as part of our research exploration we aim to follow the paths of real-life use cases, by witnessing operations by organizations located in nations, which are included in the rankings. Successful and/or promising advancements of startups belonging in the top-ranked nations will prove that the research has produced a valuable index and significant research progress has been implemented. Any issues and conclusions, which will come up with this evaluation, shall assist this research empirically and direct governmental decisions [24].

4. Experiments and Evaluation Results

Once the numerical values for each indicator were collected, the following steps were conducted for automatically computing a single score per country serving as the respective Blockchain Readiness Index (BRI).

Step 1: Normalization of data. As a pre-processing step, all indicators' values were normalized as follows. First, all the non-already-normalized values (i.e., values coming from other indices) were normalized according to the population of the respective country. Second, all values were normalized according to a max-based scheme in order to fall into the [0, 1] interval.

Step 2: Definition of a reference country. To the best of our knowledge, there is no analytical form (e.g., a mathematical formula) that enables the calculation of the target index taking as input the indicators' values. For this purpose, we are introducing the concept of a "reference country" which stands as a virtual (i.e., non-existent) country exhibiting the best possible performance with respect to the considered indicators. This "ideal" country was generated as follows: for each indicator, we explored the available values of all countries and we retained the best performing one.

Step 3. Computation of similarities. The similarities between each country and the reference/ideal country defined in Step 2 were computed. This was performed by vectoring the indicators' values and calculating the *cosine similarity* between the respective vectors. Cosine similarity is computed using the following formula:

$$similarity(A, B) = \frac{A \,.B}{\|A\|\|B\|}$$

Step 4. Ranking of countries. In this step, the underlying assumption is that a country exhibiting high BRI is expected to be similar with the reference/ideal country since the latter exhibits the best possible indicators. Under this hypothesis, the similarity scores computed in the previous step were used as BRI scores, while the countries were ranked in descending order.

An indicative excerpt of the outcome of Step 4 is shown in Table 1. Specifically, we are presenting the *top*-ten countries along with the corresponding BRI scores (in descending order).

Table 1. Automatically computed BRI scores (*top*-ten countries).

Country	BRI score
Singapore	0.902
Canada	0.854
Luxembourg	0.839
Switzerland	0.832
Malta	0.830
USA	0.824
Netherlands	0.823
Slovenia	0.816
Estonia	0.816
Iceland	0.810

We observe that the auto-generated scoring is quite reasonable since major economies have been included (e.g., USA, Canada, and Singapore). Also, smaller countries/economies having strong blockchain adoption (e.g., Malta and Estonia) have been also automatically inferred by our BRI considering our indicators from Section 3.

In addition to the above qualitative analysis, a systematic effort for the construction of a quantitative BRI ground-truth is currently under development. Our goal is to aggregate and analyze BRI scores from numerous (and independent) blockchain experts for each country. Specifically, we aim to collect more than 100 individual responses for each country. In this work, we briefly report evaluation results using a preliminary version of the algorithm, comparing the computer results with the intended ground-truth (20 responses per country). For each country, a single BRI score was

calculated by averaging the respective responses. The Spearman's rank correlation coefficient between the ground-truth and the auto-computed BRI scores was used as evaluation metric. For the countries/scores mentioned in the above table, this correlation coefficient was found being equal to 0.55. This coefficient suggests that the outcome of our methodology is positively correlated (and well beyond randomness) with the average human judgement indicating the validity of the overall proposed approach.

5. Conclusions

The proposed methodology is expected to produce an index able to capture the propensity of nations to adopt to Blockchain technology and exploit the benefits of this emerging area [25], contributing to a wider adoption of an innovative concept.

We plan to empirically evaluate the proposed index on a global scale. The expected outcome is that organizations and individuals operating in this industry are able to run their operations more efficiently in top-ranked nations rather than lower-ranked nations. This research will also be helpful for governments, startups, individual investors, crypto-enthusiasts and academics as useful conclusions will be drawn which can assist in their decision making and political/legal management. A further aim of this research is to provide developing nations [26] with certain resources and paradigms [27] to be used for enhancing blockchain adoption which could be the solution for many internal processes. Furthermore, several researchers will be able to use the outcome of this research as a tool, which assists on the evaluation of the blockchain/cryptocurrency landscape within a given region. The assumptions, directions and components of their research work could be based, at a certain level, on the development of our BRI.

An interesting property this work is that the proposed index has the flexibility to be updated regularly. This is because the development of more relevant sources through the years will affect the scoring indicators and will contribute to the validity of the index, as well as, to serve the managerial and socioeconomic aspect.

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