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Technology Assessment: Exploring Possibilities to Encounter Problems Faced by Intellectual Property through Blockchain

M. Ismail, E. Grifell-Tatjé, A. Paz

***Abstract*—**A significant discussion on the topic of blockchain as a solution to the issues of intellectual property highlights the relevance that this topic holds. Some experts label this technology as destructive since it holds immense potential to change course of traditional practices. The extent and areas to which this technology can be of use are still being researched. This paper provides an in-depth review on the intellectual property and blockchain technology. Further it explores what makes blockchain suitable for intellectual property, the practical solutions available and the support different governments are offering. This paper further studies the framework of universities in context of its outputs and how can they be streamlined using blockchain technology. The paper concludes by discussing some limitations and future research question.

***Keywords*—**Blockchain, decentralization, open innovation, intellectual property, patents, university-industry relationship.

I. Introduction

BLOCKCHAIN is part of a wider technology known as distributed ledger technology. The word blockchain is commonly used in the context of the electronic currency and is highly associated with Bitcoin. This technology is being remarked as a disruptive technology and the fifth computing paradigm [1]. Blockchain gained recognition in form of cryptocurrency ´Bitcoin; however, the uses have been expanding along with the investment and modification in law to support it.

Blockchain´s main features include decentralization, security and irrefutability. These features make blockchain an ideal medium for protection of intellectual property. This idea of securing intellectual property through blockchain has been gaining a considerable acceptance. The traditional strategies to protect the intellectual asset vary with the nature of the property itself and its future use. Blockchain can be used as an open system or it can be a developed as a private and permissioned system for protection of intellectual assets.

Amongst various bodies that are involved with creation of intellectual assets, universities have a considerable share. This share has evolved with time in response to the changing dynamics of the society. Universities have acted by adapting to these needs and have broadened their scope of work from being just a teaching institute to having specialized in research and the entrepreneurial partnership [2]. This involvement has led to creation of intellectual wealth which requires protection for commercial or noncommercial use.

This paper examines the uses of blockchain for protection of intellectual assets, its legal and commercial acceptability. Second part of the paper search for ways to use blockchain and replace or improve the current transfer and protection strategies of university´s output [3].

The study is based on the original idea first introduced by a writer who published his work under a pseudo name Satoshi Nakamoto [4] which solely talks about the use of blockchain in context of the currency. The use of same technology for protecting the intellectual asset has been discussed in many short articles and technology magazines. The in-depth research work was conducted by Martin Zeilinger who explores the possibility to create markets for digital art using the blockchain technology and replace the traditional copy right system [5]. The other brief proposals on uses of blockchain include digital identity system, freedom of speech, governance system, democracy and voting system [1].

This paper adds by studying other intellectual property protection strategies, the acceptability of this idea amongst investors and governments. This study introduces the application of blockchain as a complete solution for any academic or research institute under the framework of technological innovation and intellectual property.

The research method used to conduct the study is monitoring and intelligence method for forecasting technology (see Appendix) [6]. The research is based on research papers, research articles, chapters from books, expert opinions and study of the support extended by several governments for this technology.

The objective of this paper was to develop (a) understanding of blockchain and intellectual property (b) analyze what makes blockchain ideal solution for intellectual property (c) sketch the main functions of a university and how blockchain can support them.

The next section of the paper discusses the broad aspect of intellectual property and the strategies used for its protection, followed by explanation of blockchain and how can it help overcome the weaknesses of the existing system. The last section explains role of universities and how blockchain can help to make things easier with respect to intellectual property

M. Ismail is working as a Post Graduate Researcher with Universidad Pública de Navarra in the Field of Open Innovation, Spain (corresponding author, e-mail: muhammad.ismail@unavarra.es).

E. Grifell-Tatjé is currently Professor of Management and Business Economics in the Department of Business at the Universitat Autònoma de Barcelona, Spain (e-mail Emili.Grifell@uab.cat).

A. Paz is Executive Director at Knowledge Innovation Market, *Spain* (e-mail: apaz@kimglobal.com).

and other outputs generated by universities.

II. Intellectual Property

Intellectual property is defined as negotiable objects including but not limited to original ideas or research, innovation, knowledge and invention for industrial or scholarly purpose by the World Intellectual Property Organization [7].

Others define intellectual property as ´Engine of production´ [8], the firm´s ability to produce beyond its tangible assets – land, machinery and equipment as described by Quinn [8].

Poltorak and Lerner [9] described intellectual property as a creation of human awareness and imagination…an intangible, an object missing physical state…beyond the concept of dimensions and Aristotelian senses. It carries economic value and can be protected or kept as security, can be created in matter of a moment or may take strenuous years.

The definition itself signifies as to why intellectual property holds such great importance to an organization as well as an economy. Intellectual property is an important element for the growth, since it offers strategic competitive advantage [10]. The combinations of various intangible assets form capabilities that are not replicable through sole use of physical assets.

Lehman [11] bases the growth of the US economy on three factors, globalization, conceptualization and application of new technology and move to knowledge-based economy. The end product of conceptualization is the intellectual property, which has been a source of competitive advantage for countries contending for the global dominance. The increase in rate of creation of such intellectual assets is owed to the ease of communication and flow of ideas in recent times. This decrease in cost of communication has resulted in lowering of the operational cost for idea creation, hence providing more opportunities to those who would not be involved in research otherwise.

The tradeable attribute of intellectual property is another dimension which further amplifies its value. This trait provides an opportunity to the entire supply chain of the intellectual property to economically benefit from it. The producers of intellectual property can gain by selling and the buyer can use it to cut manufacturing cost, escalate output, and introduce an advanced or even a completely original good.

In light of the understanding that has been established around intellectual property, we shall try to narrow its scope for dedicated applicability to the context of universities. University´s Intellectual property can therefore be defined as research work, publication, scholarly work, scientific discovery, software, human samples and other property that can directly or indirectly be used by university or transferred to an entity for purpose of value creation. For the purpose of this paper, we shall use words intellectual asset and intellectual property (IP) interchangeably.

III. Intellectual Property Rights

We can find an interesting case of intellectual property right going back to 500 B.C. when the Greek chefs living in Sybaris received time bounded exclusive rights for preparing certain types of cuisines [12]. Intellectual Property right is the exclusivity given to an individual or an organization for the use or disposal of creation of mind in exchange for economic rents. This right is obtained through the filing of protection or establishing the right of first use amongst the other available options.

There are three philosophical viewpoints that reason for the legitimacy of the intellectual property rights. The first is the perspective model which is based on John Locke´s labor theory of entitlement. The theory argues regarding the involvement of labor and effort in developing of intellectual asset which therefore provides a right to protect it. Georg Wilhelm Hegel´s philosophical opinion states that intellectual property is an augmentation of individual personhood and self-ownership, justifying the ownership to what is actually a face of one´s expression. The third concept is based on the utilitarian model which maintains the concept that if an idea is contributing to the well-being and growth of the society, the intellectual property right will act as an incentive for future growth [5].

The same technology that eases the communication process and allows for creation of ideas at an increased rate is also responsible for its imitation. Once the idea is copied, the inventor loses the competitive edge that allows him/her to recover the large upfront cost. The increase in opportunity cost discourages the inventors to involve in a process that has high uncertainties attached with it. The presence of a balanced system hence protects the right of the innovator to earn increased rents for a defined period thus encouraging future innovation.

Given the increase in importance of the intellectual property, it has attracted attention of national and international policy makers. A well-designed intellectual asset has ability to improve the production capacity of an entire country. These rights are obtained in various forms by the inventor, ranging from a patent to defensive publication. Every inventor goes for a different form of protection that is mostly backed by the legal system of each country. The selection of the type of right is referred to as the strategy, which depends upon the aim and goal set for this intellectual property.

A. Strategies to Protect Intellectual Property

Each type of intellectual asset requires a different strategy for protection based on its property and the future usability. An asset which is to be made exclusive can be patented, where as an asset which is to be used for building a future solution may be kept as a secret till the technology has matured.

1) Patents

Patent is defined as a sole right to use the product or the process that is an original way of carrying out a task or is a procedural resolution to a problem. The holder of the patent has the right to prevent anyone else from using or developing

it for economic benefits for a defined period of time. Against this patent, the inventor must publicly disclose the technical information pertaining to this asset. This exclusive right to use an intellectual asset can be delegated or shared by the owner with another user, partially or fully, in exchange for commercial consideration [13].

The patent guards the interest of the owner and provides him/her a right to utilize his/her idea and have a competitive advantage in form of monopoly or exclusivity. The use of patents has evolved from being used merely for defense against replication to gain financial return through using it for further licensing and generation of royalties [14].

Patents are systematically granted under the prevailing patent laws, against the detailed information regarding the design and the possible uses. A patent is by no means a vehicle to commercialize the intellectual asset. The strategies to commercialize an intellectual property differ and include but are not limited to licensing or agreements. A patent only provides the right to protect it against being used by non-holder of patents for a specified time.

A patent is granted only if existence of any prior art is not established during the assessment phase. However, this publication or prior art must exist at least for a defined period of time. For example, for filing a patent of medicine, if a same form of formula already exists for at least 12 months, the patent would be rejected. Minimum grace period required to prevent registration of the patent vary from six to twelve months depending on the law of country. Countries including USA, Canada, and Australia have a grace period of twelve months, whereas Russia and Japan have a six-month grace period [15].

Only new ideas can be protected through patenting and not the incremental changes in the existing asset. The incremental changes are referred to the slight alterations in the form or uses of a product, yet they cannot be protected with this system.

Patent is only granted to the items that are at the stage of industrial application, which means that they must be ready for application and must not be just in theoretical stage, which is further described as a form in which the intellectual asset is ready to be used and can be recreated following the steps indicated by the inventor.

Patents have limitation when it comes to the global application, many countries based on their laws do not allow patenting of items such as mathematical models, discoveries, medical treatments or computer programs [13].

Since an asset can only be patented when it reaches the stage of application, there is a risk that a competitor might register it before, completely restricting the innovator to financially benefit from his own creation. In the other cases, if the patent is not too strong, it can lead to competitor filing a patent against the innovator. These combined with the issue of complexity in the patenting system and lack of uniform policy globally discourage inventors to go for patenting system.

The patenting system itself is sometimes misused by patents trolls or the non-practicing entities, these firms obtain the right of multiple patents with intent of earning through licensing and litigation rather than producing own goods or services [16].

2) Trade Secrets

World intellectual property organization defines trade secret as a process of holding a commercial secret that may deliver economic advantage. Unlike patenting, the trade secret is not registered and is limited to be used a defensive strategy. Trade secret offers protection of items that may include but are not limited to sensitive information, formula or information about customers or clients. Ideally trade secret is effective in conditions where the invention possesses high degree of complexity and its holder is confident regarding the measures, he/she has taken to keep it protected [17]. Secrecy can sometimes turn out to be an uncertain strategy since secrets tend to leak [18].

The decision of using a defensive or aggressive strategy for securing an intellectual property depends upon the motive of its use or the stage it is in. An invention which can have continual improvements in its design and are not so significant might be better off under trade secret protection.

The increased university-industry collaboration especially in the sector of biotechnology has given birth to number of intellectual assets [19]. These assets may be further developed and used by the industrial partners for commercialization once they attain a certain stage. During infancy, it is mostly not possible to protect these assets through patenting as applicability of the idea is one of the compulsory requirements for patenting. An idea or a future solution in the testing phase may not be able to fulfil this requirement and may not be able to get protected through patent. The only solution at this stage is therefore to keep it as a secret until it is mature enough to show signs of use and might be patented if feasible. In other cases, holders of intellectual assets may voluntarily choose to use trade secret as a protective strategy to circumvent the considerable cost attached with patenting. The incremental changes that cannot be patented can also be held as a secret, these could be in form of the increased production efficiency or just some modifications in an asset. Increased efficiency is also held as secret since patenting would require disclosure of this information, leading to loss of competitive advantage.

The risk attached to holding intellectual asset as a trade secret lies in the possibility of competitor attaining a patent of similar asset completely barring the innovator´s right of use. This can be prevented if the defendant is able to prove his prior user rights, this is the “user right is the right of a third party to continue the use of an invention where that use began before a patent application was filed for the same invention [20].

This policy takes into account the fact that various intellectual assets are not and cannot be patented, therefore it provides security to the trade secrets, it could be commercial viability or the fulfillment of requirements itself which prevents it from being patented.

For trade secret to be eligible for prior use defense, it is vital to prove that the intellectual asset is held and being used for more than a year prior to the date the patent was filed by

anyone else.

3) Defensive Publication

The use of trade secret as a defensive strategy can turn out to be risky based on the uncertainty of leakage that is always prevalent. In some cases, trade secret can fail if another entity files a patent on similar type of asset, this patent will take away the right of inventor to use his own idea or creation. In these conditions, defensive publication is a viable solution, which can be explained as public disclosure of an invention or an idea to deter competitor from issuing a patent which has similar functionalities for the commercial purpose.

When compared with patenting, the cost of defensive publication is significantly low and can be used for assets that have uncertainty attached with chances of success or failure in future. Merck pharmaceutical in collaboration with Washington University in St. Louis went for defensive publication instead of patenting the "Merck Gene Index" resulting in substantial reduction of cost [21].

For any asset to qualify for patenting, it is first compared with any similar asset that is publicly available, this publicly available asset prior to existence of patent is known as prior art. The prior art needs not to exist in physical state and can be in form of description, this condition qualifies defensive publication as a prior art.

Another flexibility of defensive publication may allow the inventor to patent the core product and protect the incremental changes through publication, which otherwise could not be patented or may take substantial amount of time and money. Unlike patenting, which only registers novel ideas, defensive publication can secure any incremental or minor modification.

Defensive publication can be in form of product literature, white papers or press release in soft or hard form. If any paper is presented at a conference, the minutes or proceedings of that conference can be used as a form of defensive publication.

4) Copyrights

The right to protect the work of art and literary is termed as copyrights and broadly includes items such as books, music, software, maps, databases, technical drawings. Copy right is limited to expression and cannot cover ideas, procedures or mathematical concepts. Copy rights provide moral and economic right, the moral right guards the nonfinancial rights, whereas economic right allows the proprietor to receive economic rent over use of his work [22].

As per the Berne convention most of countries do not require the artist to register his/her work and it is automatically covered under the said law. Some countries, however, have a voluntary registration process in place. These offices are in place to validate the ownership and creation and help to resolve any disputes that may arise regarding the ownership or the date of creation.

Traditionally the copyrightable object available on the internet lacks information about the owner which creates issue for those want to use it. There is a disconnect between the available information and the content itself which creates an extra cost to locate the owner of the content [23]. This limits the use of content and hence the revenue which would have been generated otherwise by the owner of the content. The artists who use an intermediary for the publishing of copyrighted material must share a high portion of the remuneration they receive.

The criteria defined in the law for the inclusion of art as copyright is quite narrowed leading to a coverage that is very limited out of the entire population of the art available mainly over internet. An extent of the issue related to the common availability of this information is by the virtue of the copyright law itself which is further enlarged by lack of common technology. A solution to this problem could be in form of interoperability of data through a common system. This can decrease the transaction or search cost for the users of the content if not eliminate it.

B. Open Innovation

Contrary to the traditional innovation model that only relies on the ideas generated within, open innovation incorporates ideas from both the internal and external resources alike. Henry Chesbrough describes open innovation as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expands the market for external use of innovation" [24].

The model is aimed to build upon the wheel that has already been invented rather than finding a looking for an alternative solution. This is a two-way mechanism; the other part of this model requires the internally created information to be shared the same way with the others who can further use this information and build upon. Under this model, the research and development is open, which means that it is to be shared without any restrictions.

The traditional research and development model is also known as horizontal model, where every firm specializes in one item for example components of a car, whereas open innovation is vertical integration that uses already created idea or content and build upon it or extends it. This model departs from the classic model of patenting that restricts the use of a technology and building over it. Open innovation speaks of sharing the knowledge of research which eliminates the monopoly of a single person or entity over an idea.

In some instances, the firms still hold the legal right of their idea, but they allow other firms to use it for development or research purposes. Proponents of open innovation argue that patent and patent trolls act as a deterrent to the innovation. Innovative companies are trying alternative ways to be able to innovate without facing any risks at same time. Twitter introduced a similar concept which it calls ´Innovator Patent Agreement´. They tried to ensure their patent does not end up in the hands of patent trolls but at the same time they committed only to use this patent for defensive purpose. This would encourage sharing of knowledge for those who want to study an existing technology and built upon it [25].

Tesla has taken a similar step by announcing "…. (They) will not initiate patent lawsuits against anyone who, in good faith, wants to use our technology" in the spirit of what Elon Musk calls "open source movement" as he acknowledged that

this would allow other car manufacturers to innovate on the existing technology which is better for the long term outcomes [26]. This sharing of ideas can lead to extension or modification of a product which the original innovator would not be able to come up with and can lead to the overall growth or acceptability of product. In case of Tesla, sharing of this technology would lead to acceptability of electric cars, hence creating a bigger market which will automatically increase each participant share.

IV. Technical Explanation of Blockchain

Blockchain is part of a wider technology known as *distributed ledger technology*. The word blockchain is commonly used in the context of the electronic currency which was first introduced by a writer who published his work under a pseudo name Satoshi Nakamoto [4]. The distributed ledger technology´s principle objective is to share and synchronize transactions among independent computers.

Blockchain is a shared ledger that records different transactions and stores them across a network of unconnected computers called *nodes*, without presence of any central body. This implies that each user in this network holds a copy of the ledger which is completed and updated simultaneously, this decentralization characteristic is more commonly known as *peer-to-peer* in the technical language. The data that are shared on this network are secured (encrypted) using ciphers and different mathematical algorithms under a scientific method known as *cryptography*. Cryptography makes the ledger secure and protects it against any form of interference and attacks [27]. Besides providing security to the ledger, cryptography also ensures the integrity of the data by recording the origin of each transaction to ensure there no refutation at any later stage [28].

The transactions on the ledger are only recorded in form of blocks, which are formed after combining several transactions. The transaction can only become part of a block via consensus among the entire peer community, at this stage the block is called the *candidate block*. Once the candidate block is created, it is then validated under the strict protocol defined by blockchain. Validation is a process where some nodes known as miners compete to solve a complex algorithm, and this job is referred to as *proof of work*. Once the miners solve this algorithm, the block becomes permanent part of this network ledger. These features make blockchain a unique decentralized mechanism of value sharing that works without presence of a central body. Another feature that distinguishes blockchain from any other system is its *append-only* feature which automatically records the data to the blockchain in time ordered sequence. Once the block has become permanent part of network and is followed by other blocks, it becomes near to impossible to change any information in the old blocks.

Every block that is created carries parts of some significant information with it, first being *hash* of the previous block, second is the overview of the transactions in the existing block, the time stamp and proof of work or the difficulty level that went into creation of this block. Every new block is thus child of an old block creating a chain like link between all the blocks.

Hash can be described as computer generated output in which data is converted into a unique string of alphabets and numbers that requires very less space to be recorded. The output that is generated for blockchain is fixed to 256 Bits (32 Byte) to save up the data space. Therefore, every new block that is created carries reference or the summary of the information that goes into previous block.

Trusted time stamping is another important feature of blockchain which makes it ideal for adoption as a solution to IP issues. This process records the time of the creation and modification of the file. This gives the users a confirmation of the time which protected through encryption therefore trust worthy.

Absence of the central authority and replication of old blocks summarized information into the new one is the core strengths the system. These features also make it difficult for hackers to manipulate the data since every new block has information regarding the old one and is mathematically protected [29]. Blockchain can be used as a system made open to public like it is being used for the crypto currency currently or it can be a developed as a private and permissioned system, where only a preapproved number of people within an organization can have access to the system.

A. Main Features of Blockchain that Support IP

There are two central features of blockchain technology that make it a tailored solution for resolving the intellectual property issues [1]. First is the hashing and the other is secured time stamping. Hashing is the process of converting any data file to computer readable sequence of characters consisting of alphabets and numbers, this conversion is usually done through running an algorithm over the data. The hash cannot be back computed, which means you cannot obtain the original file by running the hash. This feature provides confidentiality and security from anyone who has the hash by restricting the access the file or its contents. If the content of the files is changed, the file will never produce same hash again, hence hash can verify if there was a change made to the file. If this hash is run over the same file it belongs to, it will match confirming the file is in original form. The file can be anything including video, games, genetic codes or even a picture.

The concept behind what makes hash of great importance to the intellectual property is its uniqueness for every different file. Slightest change in the entire file that could just be an alphabet, changes the hash output in comparison to the hash that belonged to the original one. This acts as evidence confirming the integrity of the file that it has always remained in the same form since inception.

The hash allows the attestation or verification of a file, once blockchain gains more acceptance as a solution for intellectual property, it will be very difficult or near to impossible to conduct any forgery with the original documents.

The other characteristic which signifies the applicability of blockchain is its ability to time stamp. Time stamp is the simple recording of time when an event took place, the

pictures are time stamped with digital cameras to allow the user to track the date and time of the event. The blockchain instead of using a central time stamping authority uses decentralized trust time stamping process which records the time the file is created when it is made part of distributed blocks [30].

When combined, these two features provide a way forward for the use of blockchain as a solution to the loop holes in the prevailing intellectual property rights system. The core of this decentralization eliminates interference of a single person or system, thus eliminating the chances of forgery. The hash provides integrity to the files and acts as an evidence that file has been preserved in its original form. The time stamping allows the owners to stamp it as soon as they produce an idea without any time gap or delay.

B. How Blockchain Can Support IP

The prevailing laws of intellectual property, although not common amongst countries but are aimed towards a shared goal of preventing the unapproved plagiarism of the original work. However, a quick investigation divulges the inefficiencies of the prevailing mechanism and signals regarding the gap between the technology and the law that requires bridging [5].

When it comes to the basic issue of disconnect between the available content and the information of the originator, blockchain can solve this through registering the content in the name of owner by time stamping it. This stamping of the work can be used for verifying the ownership of content and create opportunity for verification across multiple systems which will strengthen the position of blockchain compared to traditionally available systems [31]. This problem is widely seen in the context of the copyrights where work of art available over internet is without the information of the owner.

Some might argue regarding difference or value addition between the currently available copyright protection systems like ContentID, used by YouTube and the solution available through blockchain. The lacking with traditional systems is the absence of inter-operability that connects and synchronizes the whole information together or eases the process of migration. This barrier can be overcome through blockchain and the upcoming solutions to overcome the technical constraints.

Fusion is one of the upcoming technologies providing two solutions. The first is the complete eco system in form of an infrastructure that allows interaction of all the services operating on blockchain. The second is the communication between independent blockchain systems. This feature is most vital to differentiate blockchain from the currently available systems [32].

Another distinctive advantage that blockchain offers is the smart contracts, this could enable the content creator to automatically restrict use of the content without the user agreeing to the terms of usage.

Using blockchain as an alternative or complement to the prevailing patenting system can overcome the inefficiencies faced by the system. In situations where the intellectual asset has not fully achieved the stage of industrial application carries a risk of being leaked or being registered by competition. This intellectual asset can be registered through a blockchain system and the incremental innovations can also be traced and timestamped which was not possible otherwise.

The blockchain system can also help overcome the inefficiencies in terms of the time taken for an invention to get patented. Blockchain can act as a complementary system to the existing patenting mechanism [33] or can be used independently, soon replacing the existing methods. The recording on the blockchain can be used as initial date and time of recording and when the asset is ready to be registered, the application can be filed along with the existing record for a more transparent case.

The existing patenting system is not as simple as recording a transaction, it involves thorough examination of the application, comparison with existing technologies and check for novelty and originality. A mere registration of an event cannot carry same value as a patent in term of its legal enforceability. However, with the maturity of technology, we can expect changes in business procedures and hence the change of laws. The disparity in the global patenting system coupled with the high cost adds up in favor of blockchain over the patenting system, and soon we can expect some radical changes.

Time stamping through blockchain can also provide an authentic and reliable proof of existence in case if a competitor tries to file a patent to prevent the original creator from using his own idea, whereas patent trolls will feel reluctant to invest in expensive patents if users have proof of use.

Blockchain is a suitable platform for defensive publication which allows innovator to publicly announce and protect his creation from being patented. The integrity of the blockchain system and time stamping feature is highly suitable for defensive publication, since the quality of evidence is substantially higher than a normal database which centrally operated and maintained.

The open innovation has led to various blocks of collaboration amongst firms of dissimilar sizes and participants. Most of these individuals participating in this collaboration are not compensated for their effort [34]. These uneven collaborations have led the firms to gain and Individuals to lose their precious ideas without appropriate consideration. This inequality in the relationship and asymmetry of power leads to lack of confidence amongst the potential partners resulting in resistance in the process and lowering of outcomes than expected. The same is observed with the upcoming startups based on the open innovative models where the results of some initiatives are not equally distributed.

The other problem is attributed to the natural phenomenon of competition that exists amongst individuals. Mostly everyone recognizes the importance of competition since it serves as fuel for creativity and productivity. Getting a large group of people working in the same direction can be a challenge, especially when each member desires its input to be recognized. The current platforms of open innovation lack the

means of tracking the ideas in absence of which, the individuals do not feel motivated enough to invest effort. This requires for a system that is decentralized, impartial and recognizes effort of each individual who can earn economic rent over it. The same system can also be used to raise funds for a startup. Star base [35] is one of many blockchain based funding platforms, where an investor receives tokens against his investment. Other way to invest in this firm is by providing services, these people are called collaborators who can work for an ongoing project and can receive currency known as ´tokens´ for their services.

C. Legal Acceptability of Blockchain as Solution to IP

The legal status of blockchain varies across the context of its service or solution. The laws pertaining to the cryptocurrency differ from the laws applicable to intellectual solutions. The regulations usually struggle to keep with the changes in technology owing to the frequency in change of technology or the bureaucracy involved in the law-making procedures.

Blockchain from point of view of payment mechanism has been there for a while and is being used across various platforms. The Japanese government is exploring the options to formally adopt payment processing through blockchain by designing laws to support and formalize the transaction. This payment mechanism is slightly different from the currency itself and by no means is a replacement for the Japanese currency. The payments will be regularized under the Japanese law and shall be used as a complement to their official currency system [36].

The state of Vermont in U.S. has passed a law during May 2018 that supports blockchain and development of businesses based on the blockchain. The law allows for creation of blockchain based limited liability company and a personal information protection company. This law encourages setting up of more firms by limiting the liability of managers and owners of the blockchain companies and by providing them a legal framework to operate in [37].

Blockchain in the context of intellectual property refers to evidence that can be used for settling disputes over the ownership of intellectual asset through court. This evidence must fulfil two requirements to qualify as being ´admissible ´ for presentation before a court. First is to be relevant and second is to be reliable; relevance refers to association of evidence with the case, whereas reliability denotes to the integrity of the content in form of an assurance that the evidence is in original form [38].

The reliability in terms of blockchain can be understood as its property of being irrefutable. The reliability is based on the source of the evidence that comes from the integrity of the system itself.

There are two limitations pertaining to standard digital evidence, first being the heterogeneity in the integrity of digital systems that creates the electronic signature and second is the complicated and contrasting set of laws developed across globe [39]. The problem of integrity can be addressed through blockchain owing to its secure system hashing and time stamping secured through cryptography making it temper proof. Therefore, the digital systems creating the electronic signature and are formed on the blockchain technology can be perceived to be temper proof systems. Whereas for the international laws to be consistent, they will have to be modified over time to create a smooth transition and allow for usability of the evidence created through blockchain across globe for greater protection of intellectual assets.

A judgement in the Internet Court of Hangzhou China that took place on June 29, 2018 confirms the support for the blockchain system by one of the leading economies of time. The court took a neutral stance towards the evidence that was generated through blockchain and acknowledged its tamper-proof ability and its traceability. The case was specifically in the context of intellectual property between a media firm and a tech house [40]. The acceptance of this evidence itself confirms the reliability of the evidence that courts are looking for and the fact that blockchain will be seen more often proving the ownership of an intellectual asset.

V. Blockchain Based IP Solutions

The blockchain based solutions are gaining momentum and acceptability in form of startups that are funded by public and or the government agencies. There is a rising trend in the usage of blockchain for different purposes, which include but are not limited to the intellectual property solutions. Being introduced in start of 2008, blockchain has been gaining motion and acceptance in different facets of economics. Currently we see blockchain being used for raising investment, being used as a currency and for transfer of donations in remote places.

The use of blockchain to provide solutions to the problems of intellectual property is also on rise, there are different startups that have commissioned and started providing solutions independently or in collaboration with already established companies in this business. A Swiss based law firm P&T has collaborated with a German company Bernstein for providing notarization of documents through blockchain. Bernstein is a firm specialized and formed for sole purpose of providing solutions for intellectual property through blockchain [41].

Formerly bitcoin.com renamed as notary.bitcoin.com offers limited solutions using the bitcoins blockchain network. The first paper to be notarized through this portal was Satoshi Nakamoto´s white paper written on bitcoin [42].

Based in San Fransisco, Binded provides copyrights for artistic work. This company takes the blockchain and adds smart fraud detecting tools which locates unauthorized use of art that has been protected through copyright by Binded. On identification of the use of artistic work, Binded helps the clients to earn royalties based on the proof of ownership recorded in blockchain. The long-term objective of this company is to protect the rights of artist and allow them to earn from their work which otherwise is shared over internet without authorization [43].

Blocknotary is service where pictures and videos can directly be uploaded from mobile phones. In addition to

notarizing of document it also provides the authentication of interview videos. The purpose of timestamping and finger printing interview videos is to enable remote identification of customers. This would allow the customers to remotely send their identification, saving customers time and trip to the offices and accelerate customer service by reducing the time to solve an issue [44].

Proofstack is aiming to globalize the availability of evidence related to the rights of ownership of the intellectual property. They target to provide the evidence which is based on the different legal requirements of different countries. Proofstack plans to resolve the issue of the international evidence and its acceptability simultaneously across borders. This will deter the infringement of the intellectual asset cross countries as well [45].

The manufacturer of the hardware for the mining of bitcoin Canaan has also gotten into the line of authorization of documents through time stamping as a proof of existence. They will also be using the blockchain of the Bitcoin to register the intellectual assets for their clients [46].

TABLE I
OVERVIEW OF FIRMS INVOLVED IN PROVIDING IP SOLUTIONS THROUGH BLOCKCHAIN

Firm	Services Aimed at	Country of Operation	Services Offered
Bernstien	Commercial Businesses & Individuals	Germany	Time Stamping, Record Trailing, Notarizing, Blockchain Certificates
Bitcoin.com	Commercial Businesses & Individuals	Japan	Timestamping and making documents part of permanent blockchain network
Binded	Commercial & Individual Photographers	United States of America	Copyrights of the pictures and tracking unauthorized use of them
Blocknotary	Commercial Businesses & Individuals	United States of America	Verified encryption of Interviews, Time stamping of media files, Notarizing of journals directly from cell phone
Proofstack (Copyrobo)	Commercial Businesses & Individuals	Singapore	Aim to provide the evidence of copy right locally and globally
Proof of Existence (Canaan)	Businesses involved in notarizing of documents	Hong Kong	Timestamping for proof of existence
Signatura	Commercial Businesses & Individuals	Argentina	Aimed to notarize the contracts signed between two parties remotely, digitizing contracts
Stampery	Commercial Businesses & Individuals	Spain	Certification of document or database through blockchain, confirming the proof of ownership, existence and integrity.

VI. ROLE OF UNIVERSITIES UNDER OPEN INNOVATION

Universities have lived over a significant period and their roles have evolved ever since. Historically they existed for exploration and dissemination of knowledge in contrast to the additional functions they have assumed in today's time.

At present, the universities have taken up the further responsibility of being active center of innovation and collaboration between industry and the government with the aim of improving country´s and own economic performance [47]. Scope of their work has never been strictly defined [48] and has continued to change at different points.

Universities have adapted in response to the changing needs of society and have broadened their scope of work from being just a teaching institute to having specialized in research and the entrepreneurial partnership [2]. Their research work and knowledge which is funneled into commercial projects forming a University-Industry Collaboration [49].

Universities use knowledge to learn and create process improvements or technological developments, pushing the economic boundaries outwards. This practice is also referred to as the ´third mission´ of universities, looking out for economic development in addition to the basic mission of teaching and research [50].

Based on research and innovation, universities are continually engaged in testing various combinations of methods and techniques, launching ideas, discovering new markets or opportunities that could lead to creation or destruction of monopolies [51].

The role of universities is changing in response to the push from within and a pull from the outside. This pull is backed by the accelerated growth of technology that is challenging for commercial firms to keep up with, solely based on their internal R&D departments. Consequently, firms are obliged to work under a collaborative framework of open innovation where they combine flow of internal and external information for value creation and growth of their technical boundaries [24]. This transfer and adoption of expertise, formally known as "technology transfer" is characterized as a key feature for creation of a legal relationship between university and industry [51]. Through this relationship, the commercial organizations continue to secure their competitive position and sustain their growth.

A. Motivation Behind the External Engagement

The University Industry Collaboration is established on distinct levels of relationship for fulfilment of diverse objectives set by the university and firms respectively. This relationship can comprise of a ´person-to-person interaction´ or a formal agreement between the university and the firm [3]. Regardless of the variance in the goals of these partners, there are some shared aspects of benefits that lead to this collaboration.

The commercial firms are looking for highly qualified researchers, access to advance labs and equipment or sometimes are driven by a purpose to fulfil social responsibility, beyond the interest of the shareholders or the law [52].

Universities are defined as ´Professional bureaucracies´ by Henry Mintzberg [53], thus they can have a ´Standard´ and ´decentralized´ structure concurrently. This flexibility allows

the universities to engage into commercial agreements that are relevant to the skill set that individual researchers hold for a particular job. Based on their personal relationships, individual researchers can get engaged in an agreement which leads to an outcome that would reap monetary or occasionally non-monetary benefits [18]. Scientists use their social capital to engage in such jobs for staying connected with the academic and industrial community.

The organizational level engagement is mostly reached for the commercial benefits in form of initial and continued funding from private firms or the government.

The third aspect for engagement is related with the practical applicability of the research. The universities involved in research of medicine, engineering and applied sciences have highest level of association with the industry [3].

Another dimension for this triparty relationship between university-industry-government is explained by a model first introduced as ′triple-helix′ model [54] and then improved in [55]. In this relationship, each player has an implied responsibility to fulfil. This framework explicates how this relationship plays a significant role in the creation of usable knowledge or innovation which will be used and implemented by the industry and or government.

B. Intellectual Property Rights of Universities

Owing to the changing role of universities coupled with the alterations in the legislative and the economic framework, universities are now expected to create or transfer some of the knowledge for broader value creation under the open innovation model. Purpose of this transfer can be aimed at application by the public authorities, commercial entities or self-use [56].

Specialized work in the field of science, medicine and development of soft skills is carried out by universities on the request of external partners for overall boost of economy and or the welfare of public at large.

Considerable volume of self-created research is used by the institutes for further development, teaching and publishing. Reaching to an advance stage of research based on the work conducted in past and having to halt it on someone else′s claim to it can cause loss in terms of time and finances. Universities therefore require protection against foreign claims that could hinder their progress and must protect their original work.

The universities and industries collaborate with intent of creating or discovering a very specific solution for practical industrial issues. These projects are backed by considerable investments, to guard these investments it is obligatory to defend the original work from being copied or being leaked before it is launched or commercialized.

From the commercial aspect, universities trade the ′right′ of their intellectual property to earn financial returns. For this ′right′ to be exclusive, it is essential for the universities to own it legally in the first place before entering into a contract.

Reference [57] discusses the available strategies for the universities to protect their intellectual property. The significant increase in use of protection strategies by the universities is due to the improved awareness of outcomes that a university industry relationship can have. The universities in US were empowered after the implementation of Bayh-dole act in 1980, whereas the universities in UK followed somewhat similar strategy starting from 1985. The adaption of similar policies across the entire European Union was witness by the early 2000 after which inventions produced during the course of work started to belong to the universities [58].

C. Vehicles for Transferring Intellectual Property

The transfer of knowledge, idea, innovation, technology or intellectual asset could be aimed at both, social or economic benefits. If the sole purpose of transfer is aimed on social returns, it is referred to as ′knowledge transfer′ [59]. Whereas the process that involves transfer of Intellectual asset purely for the financial returns is labelled as ′commercialization′.

Commercialization makes the intellectual asset available to customers for purpose of utilization and is an integral block in maintaining sustainable growth of an organization and the national economy. The stage of commercialization is reached after completing a sequence of activities including new product strategy, idea generation, screening and evaluation. Commercialization backs the creation of jobs, advancement in technology and achievement of overall higher living standard [60].

The transfer mechanism of intellectual property is however heterogeneous, the distinction in methods is based on the difference amongst the type of intellectual asset that requires transfer [61]. For instance, the mechanism of transferring knowledge cannot be same as the process required for transferring technology. Amongst these various available mechanisms to transfer asset, the methods that are most commonly exercised include licensing, spin off, joint venture, selling, consulting, collaboration and incubation. Through these mechanisms, the organization can transfer its intellectual asset to reap the financial gains that could be one time or continuous.

VII. Blockchain and Universities

Universities principally yield two types of outputs, one is the intellectual asset and other is the educational output in form of results and student's data. These outputs are aimed to be used for commercial, noncommercial and academic purposes [3] labeled these categories as scientific output, commercial output and academic output. The scientific output and commercial output make use of the intellectual asset for own growth, future projects of the university and for economic returns, whereas the academic output is used for student's personal record and shared with prospective employers.

Blockchain can be used as a solution for a university to ease the use of all types of outputs that it produces.

A. Protection of the Intellectual Output for Commercial or Scientific Purpose

Like any commercial entity, universities seek to protect their creation from imitators, for it involves great time and effort. Based on the type and purpose of intellectual property,

the protection strategy differs owing to the diverse nature and intended use. The use of intellectual asset created can range from commercial to non-commercial purpose.

The scientific output produced in the lab of universities as a result of university-industry collaboration is mostly commercialized and used by the firm. A number of collaborations can especially be seen in the sector of biosciences [21]. The firm for economic reasons wants to delay the disclosure of this scientific milestone until it is in stage of industrial application and can be registered through patenting, whereas the academic counterparts wish is to announce the results by earliest for recognition. This issue can be resolved through registering intellectual asset on blockchain and securing it till the asset has reached the industrial application stage and can be itemized through patenting. This will allow the lab researchers to disclose the ideas and will not leave any risk for commercial information to be leaked to a competitor.

The other alternative is to bring out this invention under defensive publication and protect it through blockchain. This strategy can save the high cost attached with patenting and register the incremental innovation which cannot be protected otherwise. Securing through blockchain will completely eliminate the risk of competitor imitating and patenting the idea since a strong evidence of prior right will exist.

Secrets created inside labs carry high risk of leakage by the researchers or someone who has access to lab. This leakage could be based on some monetary benefit or mere negligence. Registration of this secret through block chain at every point of modification will ensure its protection against any threat caused due to leakage.

A percentage of the protections filed by universities to secure intellectual property owe to the non-commercial aspect such as right to operate freely. Owing to the hybrid structure of university, the individuals within the university sometimes act without any monetary consideration [62] described under behavioral economics as intrinsic motivation. Hence, for a job which has no expected monetary return might find it infeasible to protect its creation under expensive patenting mechanism. For this type of scientific output, patenting is impractical form of investment and registering through blockchain is the ideal solution.

The other available strategies for a university include copyrighting or publication that can be in form of literature, white papers or conference minutes. These outputs can also be registered through blockchain for securing and time stamping to avoid any unforeseen disputes of future. All subsequent or relatable publication can be made part of the chain, connecting each modification to have a secured track of record.

B. Educational Output in Form of Results

Universities issue certificates or degrees as a form of formal acknowledgment against the skill and acumen gained by students during a time frame. The issuers of these certificates are authorized by virtue of the law or authority delegated by a competent body. These certificates thus hold great importance to potential employers or public agencies as much as for the students.

A certificate implicitly carries a few claims with it, a proof of skill or knowledge, evidence that the issuer is a trusted body and a promise that receiver can accept these claims as it is [63]. Large number of certificates is still issued in paper form that carries risk of falsification of contents including grades and time of issuance. This risk can be reduced by use of commonly available digital platforms; however, if the issuer or the central authority decides to collaborate with a candidate, the digital certificates can be deleted or altered on click of a button. In case of any natural or un-natural disaster, the centralized record system can fail or collapse, unless it has multiple backups.

Another limitation for common digital platform is the increasing trend in data breach, the number of successful attacks on educational institutes during 2017 were 103 percent more than the breaches during 2016 [64].

These factors combined, harm the trust between the user and producer of information, leading to lengthy and costly process of verifications of the certificates. Creation of credential system based on the blockchain technology will eliminate the need of verification offices which require high economic costs for a confirmation. The integrity and security of block chain based on its protocols can give confidence to the users which otherwise is absent in a commonly available digital platform.

Sony has announced a global educational blockchain website that shares the academic records and results in an open and safe way [65]. The service can also take information from different institutes in different formats and integrate it with the previous gathered information. The system generates digital transcripts for onward submission to different bodies in a secure trustable format that cannot be tempered. The added features to this service include use of artificial intelligence that examines the data and suggest revisions in the curriculum.

MIT has initiated issuance of digital diploma to some nominated students of Undergraduate, Masters and PhD. These certificates are registered through blockchain making them highly secured and verifiable independently [66].

C. Commercializing of the Output

Universities commonly focus substantial part of their resources on the researchers and infrastructure availability. The researchers and infrastructure are essential for conducting experiments and converting the tacit knowledge to applicable knowledge, however, the researchers and students lack the exposure or expertise in transferring or commercializing their intellectual work. The process of transferring this work to the right party is fundamental in receiving compensation needed to cover the sustained cost and financing future research.

Amongst others, the industrial counterparts often identify absence of the central authority and operational cost in form of identifying the authorized person for developing agreement as biggest hurdles while going into contract with universities, also known as ´Innovation Paradox´ [67].

The variance in the research orientation of university and industry acts as another barrier for the university industry

collaboration. The absence of a centralized authority adds to the difficulties of both the partners who find it challenging to recognize and align objectives.

In view of open innovation model, both the user and the contributor must have a flawless mode of communication that can support smooth exchange of newest ideas that would result in improvement of the technology or economy [24]. This characterization supports the idea of having a communication channel where both the university and the firm face no trouble in understanding and carrying out their part of commitment.

The said issue is addressed through creation of a Knowledge Transfer which is more commonly known as a Technology Transfer Office (TTO). This office is aimed at spotting commercial or governmental firms that could possibly be partnered on the university´s ongoing or completed research projects. TTO is also responsible for authenticating the internal creation and its legal protection. The role of TTO has evolved from being an internal department to an autonomous entrepreneurial department, which looks over the entire process of technology transfer [68]. The technology transfer office is thus responsible for identification of commercial opportunities, marketing of the scientific creation, networking with the industrial partners and most importantly to get into commercial contracts on behalf of the internal researchers and university.

Part of this process can be facilitated and made more efficient through implementation of smart contracts. The concept was first introduced in 1993 by Nick [69] and has gained practical applicability with the advent of blockchain. A smart contract is defined as "a secure and unstoppable computer program representing an agreement that is automatically executable and enforceable" [27]. Smart contracts are self-executing contracts written in code form onto the blockchain. An automatic trigger at a predefined condition is set off which completes the transaction as per the terms of agreement. The confidence in execution and safety of contract is established on the security protocols of blockchain. The contracts through this process are transformed into coded language that is saved on multiple decentralized computers that are operating blockchain ensuring equal distribution of information. This also guarantees the confirmation of service delivery and payment receipt recorded in the secured blockchain ledger.

In addition to bringing ease to the parties, it also saves the cost of agents or lawyers who track the status of contracts. Its main object is to cover the terms of contracts like payment terms, confidentiality and even enforcement [63].

VIII. Conclusion

Based on the potential of the blockchain we see the increasing participants providing solutions for securing the intellectual asset. Blockchain has certain features which make it ideal for protection and these features can be benefitted using public or private blockchain. This increase in acceptability backed by the law has given confidence to the investor and can soon be seen as complete replacement of the traditional system [70]. If the system is adapted as a public system similar to the cryptocurrency, it can have limitations such as network size, complexity and governance mechanism.

Currently the patenting mechanism involves thorough study of an idea and comparison with any existing registered or unregistered similar idea. On the other hand, the registry of any intellectual asset through blockchain can be done without any prior research of existing assets. If there is a need for a central body to carry out this comparative, the key advantage of blockchain in form of decentralization becomes impractical. The blockchain system in its existing form may be used as an alternative to protection strategies other than patenting and can be used as its complementary system. On contrary, open innovation model goes against the concept of one´s monopoly and in near future we might witness the traditional patenting system fading out. Legislators can use this study to assess the changes that are to come and can lead to economic advantage of those who capitalize the opportunity.

The use of blockchain in an academic setting is on rise as we witness solutions that protect academic output have already been introduced and implemented. This study is limited in terms of practical application since the technology is in the acceptability phase. The maturity of this technology is predicted to be achieved by year 2025 [27]. The maturity of technology can provide with increased data to test it against the existing mechanism in terms of the economic and non-economic benefits.

The technology is in the real implementation phase [27] and at this point it is objective for future research to explore other institutes where it can be implemented. The studies can use further advance research methods and conduct primary research repeated with gaps to examine the deviation in opinions of the experts. The studies can also explore other distributive ledger technologies that might carry some elements that can be more efficient to resolve the patenting issues.

Appendix

Fig. 1 Problem Defining – research method for technology forecasting adapted from [6].

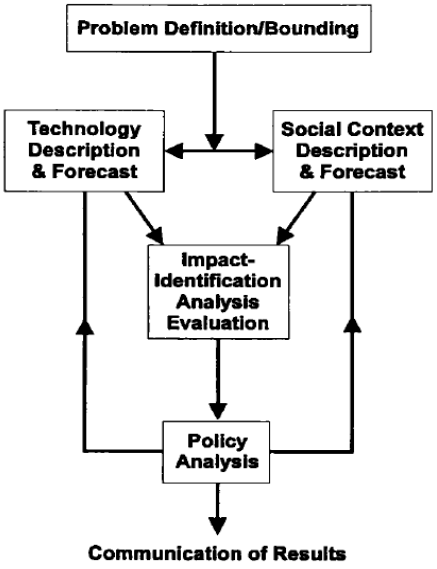

Fig. 1 'First step is to bound the focus around concerns that need contextualization, followed by how the technology is likely to evolve over time with emphasis on functional capabilities. The societal context studies key influences upon this technology, the impact analysis talks about "what might result" "how much" and "so what". All these analyses are combined to assess the prospects and consequences under policy analysis followed by communication to all interested parties'

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