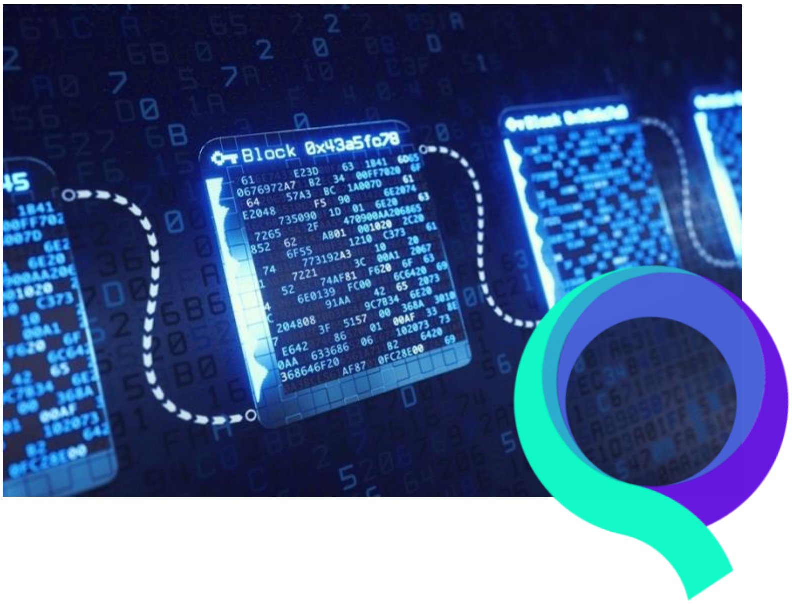
Examining the impact of the adoption of blockchain technology in universities

Bachelor Thesis by Riccardo Murciano



Maastricht University	School of Business and Economics
Location & Date:	Maastricht, 20/06/2021
Name:	Riccardo Murciano
Student ID:	i6216460
Student email:	r.murciano@student.maastrichtuniversity.nl
Programme:	Economics and Business Economics - EMI
Course:	Bachelor's Thesis Economics and Management of Information
Course code:	EBT0004
Supervisor:	Anant Joshi
Word count:	4937
Number of pages:	26

Table of contents

1. Introduction

Blockchain is the emerging technology of a new computer wave, much like PCs and wireless routers were in the 1990s and 2000s, and mobile phones were in the previous decade. There is plenty of space for creativity, and researchers anticipate the emergence of numerous winners (Andreessen Horowitz, 2022).

However, its effectiveness has been discovered only in recent times. Yet, research conducted on this infrastructure set up in 2008 by the unknown individual who identified himself as Satoshi Nakamoto has shown that blockchain technology offers a new set of tools for the security of information transfer (Taylor et al., 2020).

This study proposal will investigate the impact of adopting BC (blockchain) technology to improve the educational sector by focusing on the use-cases of smart contracts, mathematically verifiable programs that run on blockchain technology when imposed set of conditions are met (Mohanta et al., 2018). In research conducted by Catalini & Gans (2020), smart contracts offer a better alternative to contract enforcement uncertainty (i.e., human error). With this relatively new toolkit, businesses have implemented the technology in their supply chain, solving problems like inconsistent tracking updates and temperature levels in the food industry example proposed by Duan et al. (2020). Its implementation is vast and comprehends sectors like healthcare, energy management, and the Internet of Things (Zarrin et al., 2021). Such technological application of smart contracts currently focuses on notarization purposes (Chowdhury et al., 2018). BC notarization techniques increasingly show a new method to overcome centralized network issues. On this account, a blockchain operates on a decentralized network in which every node pursues the task of verifying the transferred information. In addition, this structure enables every connected entity to access the information transfers in an encrypted manner. The technology stores information in blocks on which new information is continuously added using complex mathematical encryption methods, making the data impossible to tamper with. (al Ahmed et al., 2022)

One might think that blockchain technology only has positive toolkits to offer. Although, with such great innovation, some factors inhibit a successful and risk-free adoption of BC. In the first place, the lack of blockchain expertise in current times shows that knowledge in the sector is scarce and can be an essential constraint for finding the right experts to contact for such assignments (Brown, 2021). Furthermore, data regulations, especially in the EU area, are increasingly stricter, and in the field of blockchain, it is even nonexistent to a certain extent (Al-Zaben et al., 2018; Finck, 2019). Lastly, only a minority of companies today successfully implemented blockchain technology for daily business processes, which can contribute to the reluctance of an institution to adopt such an alternative when current data management systems are more popular and common.

This research proposal aims to address a gap in the current literature by offering a way to investigate the enablers and inhibitors of a successful BC implementation in the educational sector. Hence, this study proposal tries to answer the following two central questions:

I.

Does blockchain technology represent a better alternative to current data management tools for educational institutions?

II.

Does the present standpoint of the blockchain "know-how" inhibit a successful adoption of blockchain technology?

The aspects mentioned above on how BC functions are crucial to introduce the reader to the following sections: first, the paper offers a literature review on what we know about BC today. Second, I will investigate how this study can fill the literature gap in BC implementation. Third, this essay will provide a complete overview of which aspects enable and inhibit the adoption of BC technology in education. Fourth, I will suggest a method to review and analyze the readiness of such adoption in universities through a survey with a respective questionnaire that deals with the research hypotheses in earlier sections. Lastly, I will summarize the main concepts and expose which aspects are valuable for future research in the sector.

2. Literature review and RQs

i. Blockchain technology and its applications

Satoshi Nakamoto suggested the first concept of blockchain, namely "Bitcoin". It soon became the earliest form of cryptocurrency with no centralized regulating entity in charge of issuing currency and directing financial transactions. Five years later, the young programmer Vitalik Buterin and other mathematicians and cryptographers founded Ethereum Blockchain. This decentralized blockchain has the special quality of enabling other people to access and build their blockchain (Tapscott & Tapscott, 2016). Through this toolkit, Quadrans Foundation, a fitting example for the potential of this technology, created its blockchain (Battagliola et al., 2021).

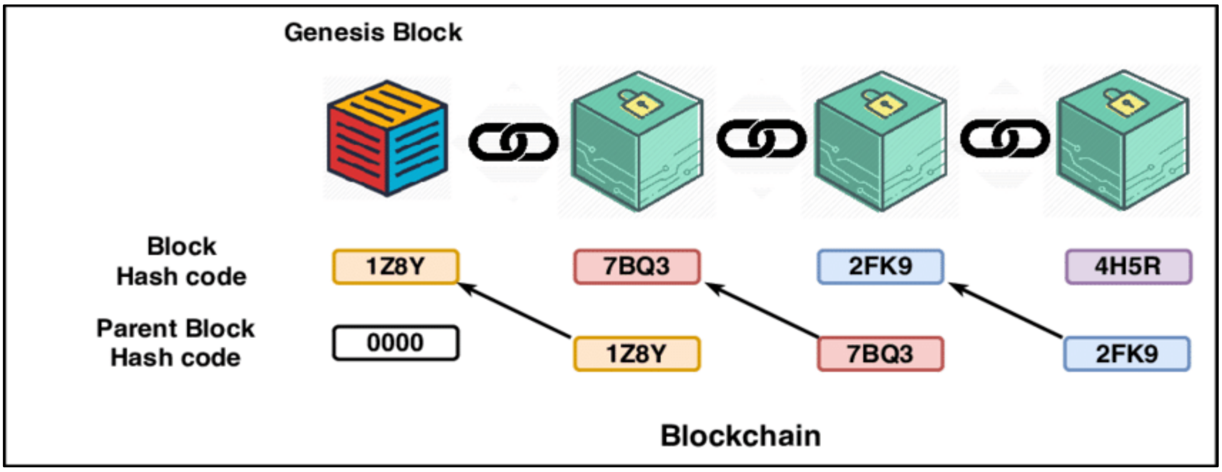


Figure 1 - Retrieved from Torky, M., & Hassanein, A. E. (2020). Integrating blockchain and the internet of things in precision agriculture: Analysis, opportunities, and challenges. Computers and Electronics in Agriculture, 178, 105476. https://doi.org

Figure 1 serves as a general overview of how a blockchain operates. The fundamental components of a blockchain are the nodes, which record the newly added data and broadcast it to the network. Nodes receive this information and enter a verification process to store the data in a block. Subsequently, every node in the system carries out a mathematical operation that changes with respect to how the network's requirements and rules have been set up. Such an operation is called "mining". The mathematical algorithm must receive verification from the nodes. Once the validation is complete, the new block is added to the blockchain, and this change is updated to all nodes. What is trying to be achieved with this method is to make any change to the blockchain as complex and challenging as possible, an aspect that shows BC's powers in cybersecurity applications (Ahmed et al., 2022).

There is not only one way blockchains are built. This is why it is important to differentiate its categories. Al Ahmed et al. (2022) explain that there are two main types of BC to be considered: *permissionless* and *permissioned*. Konashevych (2019) may argue that a *permissioned* cannot be called a blockchain because it is not built in a decentralized manner as there is a central authority operating, similar to open-source networks like Android and more. Differently, *permissionless* blockchains pursue the authorization procedure through a "majority" consensus protocol, meaning that 50%+1% (PoW) of nodes or the ones with the highest stakes (PoS) inside the network are enabling a successful and verified operation (Cao et al., 2020; Tapscott & Tapscott, 2016).

ii. The adoption of blockchain in the educational sector: Motivation and research gap

Research on implementing blockchain technology in education is limited. Current findings focus on the notarization processes in business processes (Chowdhury et al., 2018). Thus, it is important to address this academic gap in the literature concerning the impact blockchain technology could have on educational institutions.

With the given technological advancements, new disruptive computation machines such as quantum computers provoke the urge to have a cyber-secure digital system that can withstand large cyberattacks will be of higher importance (Denning, 2019). Nonetheless, universities and, more specifically, UM (Maastricht University), suffer from cyberattacks operated by hackers, and more anticipation and preparedness are crucial for the future (Kenniscentrum Cybersecurity, 2020). One may realize that what a small group of delinquents were able to do in months is just crumbs compared to quantum computers' capabilities. Thereof, cybersecurity will require a new standard. Educational institutions must take action to avoid future ransomware and data compromising that UM suffered firsthand.

The attention of academia arose not from the data handling but the social appeal of the blockchain (Buterin, V., 2015). Current research shows that the technology could contribute to data verification, ECTS attribution, and to a certain extent, diploma verification and certification (Kosmarski, A. 2020). It is claimed that these are only possible because of blockchain's principal advantages: decentralized anatomy and successful peer-to-peer interactions that do not require central governing (Zwitter & Hazenberg, 2020). However, theory dominates practice in this regard, making many claims more difficult to trust. To further elaborate on the ECTS attribution, an academic article by Costa (2020) explains how so-called e-certificates (issued by universities) can impact the education sector by validating grades and CFU credits using Quadrans. E-certificates are unique digital assets that verify the e-WMS participation. The user may establish ownership and show everyone that the authentic source that created the certificate is the issuing participant. This is enabled by e-certificate or smart contracts. Students then may obtain a digital, immutable, and non-transferable version of credentials that confirm their educational past. An example is shown in Figure 2 below:

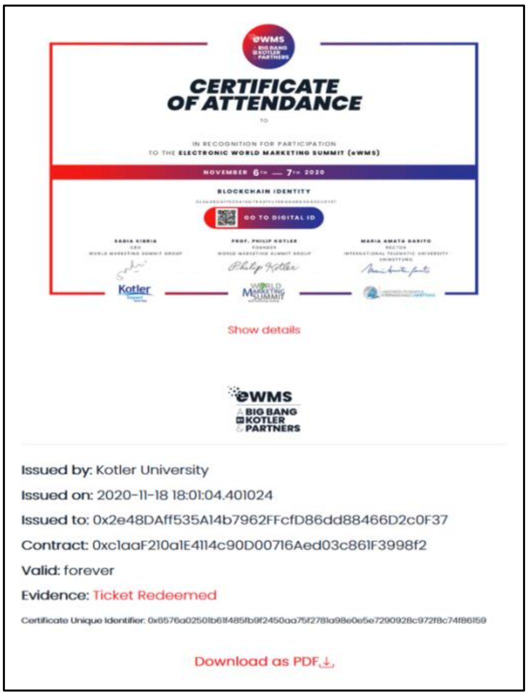


Figure 2 - Retrieved from Costa, C. (2020, December 14). Kotler Impact and Foodchain S.p.A. together for the creation of an innovative e-learning platform. Https://Www.Linkedin.Com/Pulse. https://www.linkedin.com/pulse/kotler-impact-foodchain-spa-together-creati

Nevertheless, blockchain has more to offer. Many other processes that involve sensible data management can run on a blockchain. There are countless ideas on where to implement it, and the more an implemented blockchain grows (online nodes), the more secure its transaction will be. For example, Quadrans BC currently operates on 437 nodes, and this information can be checked on the website accessible to anyone "https://status.quadrans.io/".

iii. Enablers of the adoption of BC in universities

In this section, I will investigate three main aspects of BC technology that should positively impact the willingness to adopt such technology in the educational context: cybersecurity, sustainability, and notarization. These will be explained in further detail and are part of the major proposition about enabling aspects of BC below.

Cybersecurity

Current technology has shown that cyber-attacks such as ransomware can still cut through the centralized information systems we are used to now, similar to the *www.* protocol to some extent (Blockchains, 2021). The literature I propose underlines the effectiveness of blockchain in overcoming such flaws using a decentralized network of information transfer, groundbreaking security algorithms, and more. To provide context, literature covering a blockchain's structure and core framework is referred to as a "white paper", while a more technical one is "yellow paper". Battagliola et al. (2021) have recently presented a yellow paper explaining the pillars of their Ethereum-based blockchain "Quadrans," a suitable example of what blockchain technology offers on an institutional level. In their paper, Battagliola et al. (2021) explain that this new technology will make data reliable, immutable, verifiable, transparent, and decentralized. To assure that all these conditions are met with the current cybersecurity systems, which can get overly high (Gordon et al., 2015).

Arising academia and development in the quantum computing sector state that cybersecurity will be a topic of increasing popularity since such extraordinary computing machines will, in theory, break any current security system with, e.g., 128-bit encryption, unequivocally (Mavroeidis et al., 2018). The Quadrans BC, presented by the Italian and Swiss mathematicians Battagliola et al. (2021), tackles this issue. They show that Quadrans technology's algorithms are ready for the post-quantum era while supporting lightweight encryption for IoT devices (BC "mining" nodes), a crucial component in the so-called block signing. This key procedure makes QB (Quadrans Blockchain) so secure. These findings can prove BC's power to prepare for the future of security. Therefore, it is hypothesized that:

H1.1: Blockchain represents an inevitable new standard in cybersecurity for education institutions.

Sustainability

A comprehensive analysis of the sustainability of blockchain technology has been provided by Quadrans Foundation (2022) in their sustainability report. Hence, Quadrans BC has spent the last year researching to determine its energy footprint. According to the conclusions in the report, one Quadrans transaction consumes on average 0.000013 Watts, which compared to a google search is 20 times less energy-consuming according to Quadrans Foundation (2022) and interestingly 23.000 times considering Glanz (2011). However, the average energy consumption of such transactions is growing due to network development and acceptance. Nevertheless, its energy impact is far lower than Ethereum (16.26 billion Quadrans transactions) and Bitcoin (154.45 billion Quadrans transactions) transactions. Appendix A showcases information on further details regarding these findings.

Minimizing energy consumption is an ongoing objective in every industry, universities included (Zhou et al., 2013). Therefore, replacing or using blockchain could reduce a university's digital footprint. The underlying hypothesis is:

H1.2: Blockchain's sustainability represents an important opportunity for the fight against environmental issues.

Notarization

Universities, more than any average firm, store highly personal data of students, staff, and confidential academic documents. According to Chowdhury et al. (2018), personal information is typically spread across numerous data-custodian systems. One of the fundamental difficulties with such digital records is their ease of forgery. As a result, the data consumer, here, the university, must pursue legitimacy confirmation processes of the shared document or record by contracting the issuing authority (data custodian). Hence, there has to be a third party responsible for certification, which Chowdhury et al. (2018) would accentuate its time-consuming and inefficient facets. On the other hand, blockchain offers this distributed recordkeeping of unchangeable transactions without requiring third parties. Everything is verified, and the information's originality is mathematically extensively hard to tamper with. Accordingly, BC offers a new approach to notarization for this purpose. Thus, it is hypothesized that:

H1.3:Blockchain can replace current notarization processes because of higher reliability when compared with current data management for education institutions

iv. Inhibitors of the adoption of BC in universities

Blockchain technology has its enablers. Although, new technology also comes with disadvantages that need consideration before implementation. Therefore, I will explain the inhibitors of blockchain in this section.

Insufficient knowledge

As mentioned earlier in this proposal, the technology was first applied in 2008 as a cryptocurrency. Today, research shows the majority of people hardly differentiate cryptocurrency from BC technology (Salim, 2021). It is, therefore, common that knowledge about its true potential is easily overseen. One could assume that since the technology relies on complex mathematical algorithms and encryption formulas, the averagely educated person does not have sufficient knowledge to grasp the benefits and complexity of this technology. The analogy between blockchain and the Internet by Andreessen Horowitz (2022) proves this point: In the early stages of early interconnected computers, very few were able to see the substantial decline of snail mail or the possibility of watching movies online instead of relying on DVDs from Blockbuster (Partridge, 2008; Chopra & Veeraiyan, 2017). Accordingly, it is estimated that blockchain will have a similar, if not bigger, impact on today's industries. However, such innovation shifts do not occur overnight. People today are scarcely aware of blockchain technology as a whole. The digital media consulting company in Los Angeles, Vorhaus Advisors, released a study of over 2.000 customers on how people felt about virtual products and their interests in blockchain-enabled features. Results show that most adults who know the word "blockchain" do not grasp its true definition; 62% of the population believed that "blockchain is the same as cryptocurrency", and 48% missed the distinction between BC and Bitcoin. Even though this study was only conducted in the field of electronic games, it can grasp the lack of knowledge about BC. This proposal aims and proposes a method to fill this information gap about BC awareness. Hence, the first inhibiting factor to BC implementation can be hypothesized as follows:

H2.1: Poor knowledge in the field of blockchain technology in academia causes hurdles to implementation.

Incomplete data regulations

In 2018, the EU Commission issued the GDPR. This set of regulations represents a milestone in data management and ensures privacy and justice in the digital dimension of information. Art. 17 of GDPR Official Legal Text (2019) calls for the "right to be forgotten" and the "shall be erasable" rights. Considering the core of blockchain technology, these rights can be infringed (Al-Zaben et al., 2018), as information is claimed to be immutable. Research by Finck (2019) has tackled the recurring concern that these classes of technologies may be unable to comply with European data protection rules by their very nature, suffocating their growth at the expense of the European digital single market effort. Furthermore, the study explains that GDPR is established on the premise that there is at least one natural or legal person to whom data users can assert their rights under EU data protection. Finck (2019) also explains that decentralization aspects of blockchains that replace the single actor with many diverse participants (nodes) complicate the attribution of duty and accountability. As a result, before applying Blockchain to systems that handle sensitive data, strict regulations like GDPR have to be respected. This aspect might inhibit the implementation of blockchain. The hypothesis is denoted as:

H2.2: Current regulations on data management are an inhibitor of blockchain application.

Adoption immaturity

BC has been implemented in food supply chain management, traceability, and security (Duan, J. et al.,2020). However, as mentioned in the journal article by Mazzei et al. (2020), the application of Blockchain technology in the industry is still in the early stages. Even though 33% of global businesses claim to be focusing on developing blockchain-based tools, practical evidence is still lacking (Statista, 2022). This implies that its current main use is for experimentation and development rather than securing confidential information of public institutions like universities. A potential risk factor can be the maturity of blockchain application. BC technology has barely been present for a decade, implying that this novel technology will take time to achieve widespread adoption. Maturity is a challenge for blockchain's adoption, as it is for any new technology.

Numerous participants like Corda, Hyperledger, Enterprise Ethereum, and Ripple attempt to address the decentralized problem with their unique approach (Iredale, 2022). There are now too many disparate solutions that try to tackle the main problems but do not collaborate to standardize them. Therefore, it is crucial to set the right requirements and guarantees before opting for a blockchain service to adopt the technology since it is hypothesized that:

H2.3: The immaturity of BC data management adoption makes its application more complex, creating reluctance and inhibiting its adoption

3. Research Methodology

i. Sample and data collection

To successfully verify whether a blockchain-based system to run information transfer in a more secure and cost-efficient way is to conduct a survey investigating on cybersecurity, sustainability, notarization, shared knowledge, related data regulations and adoption immaturity. This study proposes utilizing stratified random sampling to conduct a survey among senior executives, professors, and practitioners in the field of blockchain and modern cryptography. The justification for utilizing this sampling strategy is that it allows for separating the target population into homogeneous subgroups. This can be important to assess the significance of some responses that show differences in expertise. The survey data should reflect their knowledge and opinions on enablers and inhibitors of blockchain. It is preferable that individuals have been related to universities to ensure more statistical significance on BC adoption at universities in specific. Due to the wide age range of experienced people in BC, four age subgroups will be established: 20-26, 27-40, 41-55, and 56+ years. To represent the population adequately, I propose obtaining a random sample from each subgroup: modern cryptographer, blockchain expert (coordinator of a study program containing BC-knowledge) or engineer, executives for digital innovation, computer engineers, data scientists, Business Intelligence analysts,s and Other.

The proposed survey can be published online with an initial questionnaire on whether the respondents of the survey do have sufficient knowledge in the field of blockchain to bring adequate value to the proposed research. The first survey question will filter responders and exclude those who do not meet this condition.

Considering that there are 6 main measurable items to consider as the enablers and inhibits of BC adoption, Jr et al. (2009) propose to maintain a 10:1 ratio for the population, meaning that a minimum of 60 individuals should deliver a response. Hence, I suggest reaching out to at least 300 people, considering a realistic 20% response rate.

The online poll will be conducted on Qualtrics and will last for 2 months. The survey (Appendix B) includes 21 questions, 17 of which are based on a five-point Likert scale (1 for Strongly disagree, 5 for Strongly agree). To ensure the quality of empirical data, the questionnaire considers the candidates' attention by including particle questions that have one right answer to be valid. Submissions with unengaged participation are not considered.

Furthermore, before sending out the finalized questionnaire, it is recommended to test the survey's clearness and quality by asking a minimum of 15 people to give feedback on it. In conclusion, it is important to inform the participant about their data privacy by mentioning that data will be gathered anonymously and will only have academic-related purposes.

ii. Survey Method

The survey (Appendix B) aims at measuring the potential impact of adopting blockchain. This will be done by considering how participants answered. The degree of agreement/disagreement of participants will explain whether the impact of BC technology in universities would be positive or negative. This can be analyzed by observing the degree of agreement for the statements concerning the enablers (statement 2. - 10.) and the degree of disagreement for the statements regarding inhibitors (statement 11. - 18.) of the technology. This implies that answers in the direction of the agreement for the first 10 would indicate that enablers are being recognized and therefore adoption of BC can be beneficial. Meanwhile, agreement for the remaining 8 statements would indicate the opposite, since inhibitors are negatively correlated to the fact that BC is a better alternative to current data management systems.

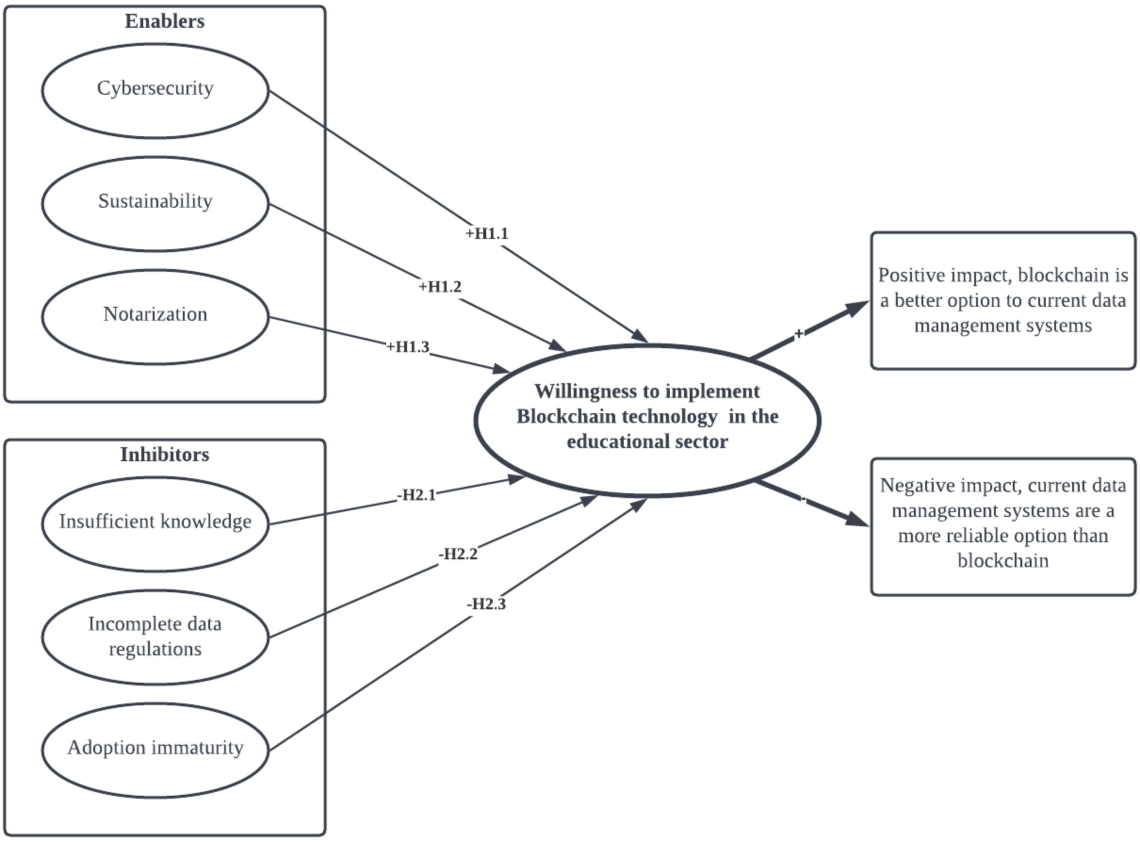


Figure 3 - Diagram representing hypothesis of enablers and inhibits with respect to the willingness to implement BC technology in universities. Generated using lucid.app (lucidchart)

Figure 3 shows the positive and negative relations of the singular hypothesis to the willingness to implement blockchain. Dependent on whether universities are willing to adopt the technology, one can assume its potential positive or negative impact. Assuming that respondents are experts in the field, the result of this research should bring value to the existing academic literature on whether to adopt blockchain technology in the educational sector.

iii. Regression analysis

The independent variable is represented by *WillingnessToAdopt* for the willingness to adopt blockchain technology in universities. It can be beneficial to give independent numerical values to determine all elements contributing to it. As previously mentioned in the literature review there are inhibitors and enablers that can contribute to the willingness of institutions to adopt such technology. These aspects were: *cybersecurity, sustainability, notarization, shared knowledge, related data regulations, and adoption immaturity.* Responses on statements dealing with enablers can be averaged into a single mean value. The same can be said for the inhibitors but considering their negative impact on *WillingnessToAdopt*. The mean values can then be used as an input sequence for the independent variable in the regression. There can be multiple regressions since the survey accounts for differences in age and occupation to have more precise statistical results in the output. *UniversityImpact* is the dependent variable and represents the impact blockchain technology would have on universities. It indicates how many participants believe blockchain is inhibited or enabled by the variables (*c,s,n,sk,rdr,ai*). The regression model would therefore look like this:

$$UniversityImpact = \beta 0 + \beta 1 * WillingnessToAdopt + \varepsilon \tag{1}$$

The proposed regression model can be further extended by including all singular independent variables replacing the ***WillingnessToAdopt*** coefficient:

$$\begin{gathered} UniversityImpact = \beta 0 + \beta 1(Cybersecurity) + \beta 2(Sustainability) + \beta 3(Notarization) - \\ \beta 4(Knowledge) - \beta 5(Dataregulation) - \beta 6(AdoptionImmaturity) + \varepsilon \end{gathered} \tag{2}$$

Model 1 investigates hypothesis 1 and 2 together, since *WillingnessToAdopt* is characterized by both enablers and inhibitors. Model 2 is the extended representation of all coefficients that intrinsically shape the *WillingnessToAdopt* variable and takes into account the respective positive and negative association of the *UniversityImpact*. This, depending on the sign of the coefficient, *Cybersecurity, Sustainability,* etc. would either result in a positive or negative willingness to adopt the BC technology, which indicates directly what the potential impact on universities might be. Figure 3 aims at showing this concept.

iv. Robustness check

Before running a basic linear regression to analyse the resulting relationships between the independent and dependent variables, it is important to ensure assumptions of linearity, independence, equal variance, and normal population. One should therefore also consider potential endogeneity issues. One, for instance, can arise when measuring the level of insufficient knowledge and immaturity. This is because there is a chance of them influencing each other. The fact that there is insufficient knowledge across people could be the driver of the immaturity of adoption. Reversely, the immaturity of adoption could be a reason for poor and incomplete knowledge. Therefore, one should account for this interdependence and this is the reason why statements in the survey are subdivided in a detailed manner by indicating which statements correspond to which topic to make sure the participant differentiates the two concepts as much as possible when giving answers. Conclusively, to compute the regression, software such as Excel, RStudio or Stata can be used.

4. Potential results and implications

After running both regression models, one should be able to draw conclusions on H1.1-3, H2.1-3, and respectively H1 and H2. H1 is verified when (1) results are significant and positive, implying that the resulting willingness to adopt is positive and shows a positive impact on universities. In case (1) should not be statistically significant, it would get hard to assess the impact BC technology would have on universities since enablers and inhibitors would balance out. Nevertheless, this outcome is more unlikely to occur and makes less logical sense. Predicting that the coefficients in (1) are significant and negative implies that the willingness to adopt BC technology is not statistically positively affecting the impact on the university. The potential impact on universities would therefore be negative. This outcome is not necessarily predicted but could contribute to the study as it would show the current state of BC in an academic scenario. Model 2 reflects the same logic, although, it extends and provides more specific relationships in order to avoid non-significant outcomes for Hypothesis 1 and 2, providing a more information-rich outcome.

Results of this research can lead to two main outcomes. One is that enablers are more considered than inhibitors, implying that blockchain is ready to be adopted. The other one is that inhibitors still have to be considered substantially, meaning that it is too early for the technology to be implemented. Although, both outcomes would contribute to enabling a complete and prudent shift to this newly discovered technology. Assuming that the outcome is showing a higher willingness to adopt such technology, universities would start roadmaps of implementation and the first one doing so could show other educational institutions what potential threats and benefits have to be considered along the way. Nevertheless, Model 2 also offers more in-depth results on what aspects are and should be considered in the field of BC advancements. For example, the regression output could show that experts are more sensible and responsive to BC being enabled by its cybersecurity capabilities rather than the notarization purposes. Results in this respect can help academic institutions to direct priorities when teaching about BC technology to fill in the knowledge gaps where knowledge is poor or ambiguous.

5. Limitations and future research

The intention of primarily sending the survey to experts in the field is to avoid the superficial and subjective points of view of people who consider blockchain a current trend or hype. Prior research has shown that knowledge in the field can be based on false assumptions, as shown in the literature provided by Brown (2021). However, this study contributes to earlier research on the adoption of blockchain. It does this by examining a broad scope of enablers and inhibitors that have never been considered altogether in contrast to previous research. The decision to focus on the educational sector is ultimately to highlight that this topic requires research and development without counting profitability and economic success, but rather the technology's true potential.

The broad spectrum of what enables and inhibits the adoption of BC is unlikely to be represented solely by the six mentioned variables. As this is a new technology, it is difficult to grasp a complete set of measures that can accurately predict its impact. For example, this proposal did not consider the chances of unemployment connected to the aspect of replacing notarization processes. This and many more could influence the impact of BC substantially. This study also has limitations in the survey design since 21 questions with a 1-5 scale of agreement could be insufficient to assess such a hypothesis. Maybe including a set of open questions that experts could respond to by explaining further why they would argue that way could have increased the validity of the results. Furthermore, it can be helpful to expand the targeted population and gather more responses that can potentially deliver valuable insights for this research. Lastly, information in this proposed setting is self-reported, meaning that individuals are more prone to overestimating their views and claims. Nevertheless, the approach has limitations that should allow for further development.

This research proposal presents an investigation approach on whether blockchain should be applied in universities, considering the impact this technology would have. Such aspects, can help researchers close gaps in the literature on blockchain applications, use cases, and potential, but also blockchain flaws and inhibitors. With adequate resources to reach out to experts in the field of blockchain, for instance, by gathering more information about a survey conducted by Deloitte (2021) on the global blockchain, this research can help underline the importance of technological, ethical, and educational advancements brought by blockchain. Furthermore, future studies may be able to construct more direct connections and more accurate claims on how these enabling and inhibiting factors can impact the role of BC in universities.

6. Conclusion

This proposal aims to fill a gap in the existing literature by examining the enablers and inhibitors of effective BC implementation in the educational sector and, more specifically, in universities. Based on this aim, it attempts to provide a method to assess such effectiveness by sending a survey to experts in the field. This can help define whether BC is still in its early stages or ready to be implemented in universities. More empirical results in this regard can help leverage the crucial aspects that must be considered in the world of blockchain and the future of how we will exchange essential and valuable information with the rise of web 3.0. Taking Maastricht University as an example, this cruciality is being tackled by professors in data analytics and digitalization. They are currently contributing to enabling collaborations between UM and a hackerspace with blockchain-related workshops that will open soon. Furthermore, with the ongoing importance and demonstrations of blockchain, as the example of Quadrans Foundation shows, fully grasping what blockchain has to offer can bring enormous advantages when considering illicit activity such as hacker attacks and inefficient data management like today's old-fashioned centralized server-network structures (Battagliola et al., 2021). Knowing what enables and inhibits the adoption of BC can therefore help institutions be the first ones benefiting from this technology and improve the most critical asset of a country, education and, therefore, universities.

5. References

al Ahmed, M. T., Hashim, F., Jahari Hashim, S., & Abdullah, A. (2022). Hierarchical blockchain structure for node authentication in IoT networks. *Egyptian Informatics Journal*. https://doi.org/10.1016/j.eij.2022.02.005

Andreessen Horowitz. (2022). *State of Crypto - An overview report*. https://a16zcrypto.com/wp-content/uploads/2022/05/state-of-crypto-2022_a16z-crypto.pdf

Battagliola, M., Flamini, A., Longo, R., Meneghetti, A., & Sala, M. (2021). Quadrans Blockchain - Yellow Paper. *Https://Quadrans.Foundation/*.

Blockchains. (2021, December 2). *Centralized vs. Decentralized: What Are the Core Differences?* 101 Blockchains. https://101blockchains.com/centralized-vs-decentralized-internet-networks/

Brown, E. (2021, January 5). *Consumers don't understand blockchain but covet what it enables, survey reveals*. ZDNet. https://www.zdnet.com/finance/blockchain/consumers-dont-understand-blockchain-but-covet-what-it-enables-survey-reveals/

Cao, B., Zhang, Z., Feng, D., Zhang, S., Zhang, L., Peng, M., & Li, Y. (2020). Performance analysis and comparison of PoW, PoS and DAG based blockchains. *Digital Communications and Networks*, *6*(4), 480–485. https://doi.org/10.1016/j.dcan.2019.12.001

Catalini, C., & Gans, J. S. (2020). Some simple economics of the blockchain. Communications of the ACM, 63(7), 80–90. https://doi.org/10.1145/3359552

Chowdhury, M. J. M., Colman, A., Kabir, M. A., Han, J., & Sarda, P. (2018). Blockchain as a Notarization Service for Data Sharing with Personal Data Store. 2018 17th IEEE International Conference On Trust, Security And Privacy In Computing And Communications/ 12th IEEE International Conference On Big Data Science And Engineering (TrustCom/BigDataSE). https://doi.org/10.1109/trustcom/bigdatase.2018.00183

Chopra, S., & Veeraiyan, M. (2017). Movie Rental Business: Blockbuster, Netflix, and Redbox. *Kellogg School of Management Cases,* 1–21. https://doi.org/10.1108/case.kellogg.2016.000220

Costa, C. (2020, December 14). *Kotler Impact and Foodchain S.p.A. together for the creation of an innovative e-learning platform*. Https://Www.Linkedin.Com/Pulse. https://www.linkedin.com/pulse/kotler-impact-foodchain-spa-together-creation-innovative-clara-costa/

Duan, J., Zhang, C., Gong, Y., Brown, S., & Li, Z. (2020). A Content-Analysis Based Literature Review in Blockchain Adoption within Food Supply Chain. International Journal of Environmental Research and Public Health, 17(5), 1784. https://doi.org/10.3390/ijerph17051784

Denning, D. E. (2019). Is Quantum Computing a Cybersecurity Threat? Although quantum computers currently don’t have enough processing power to break encryption keys, future versions might. *Sigma Xi, The Scientific Research Society - American Scientist*, *107*(2). https://go.gale.com/ps/i.do?id=GALE%7CA580224313&sid=googleScholar&v=2.1&it=r&linkaccess=abs&issn=00030996&p=AONE&sw=w&userGroupName=anon%7E69542c34

Deloitte. (2021). *Deloitte’s 2021 Global Blockchain Survey*. https://www2.deloitte.com/content/dam/insights/articles/US144337_Blockchain-survey/DI_Blockchain-survey.pdf

Finck, M. (2019). Blockchain and the General Data Protection Regulation - Can distributed ledgers be squared with European data protection law? *EPRS | European Parliamentary Research Service - Scientific Foresight Unit*. https://www.europarl.europa.eu/RegData/etudes/STUD/2019/634445/EPRS_STU(2019)634445_EN.pdf

Fink, A. G. (2012). *How to Conduct Surveys: A Step-by-Step Guide* (Fifth ed.) [E-book]. SAGE Publications, Inc.

Freeman, J. B. (2022, January 26). *Permissioned and Permissionless Blockchains | Blockchain Technology*. Freeman Law. https://freemanlaw.com/permission-and-permissionless-blockchains/

General Data Protection Regulation (GDPR) – Official Legal Text. (2019, September 2). General Data Protection Regulation (GDPR). https://gdpr-info.eu/

Gordon, L. A., Loeb, M. P., Lucyshyn, W., & Zhou, L. (2015). Increasing cybersecurity investments in private sector firms. *Journal of Cybersecurity*, tyv011. https://doi.org/10.1093/cybsec/tyv011

Glanz, J. (2011, September 9). *Google Details Electricity Usage of Its Data Centers*. The New York Times. https://www.nytimes.com/2011/09/09/technology/google-details-and-defends-its-use-of-electricity.html#:%7E:text=Google%20also%20released%20an%20estimate,be%20difficult%20to%20understand%20intuitively.

Iredale, G. (2022, April 14). *Top Disadvantages of Blockchain Technology*. 101 Blockchains. https://101blockchains.com/disadvantages-of-blockchain/

Jr, J. H. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2009). *Multivariate Data Analysis (7th Edition)* (7th ed.). Pearson.

Kenniscentrum Cybersecurity. (2020, November). *Cyber crises require anticipation and improvisation*. The Hague University of Applied Sciences. https://www.researchgate.net/profile/Jelle-Groenendaal-2/publication/345975335_Cyber_crises_require_anticipation_and_improvisation/links/5fb380fe299bf10c368615bc/Cyber-crises-require-anticipation-and-improvisation.pdf

Konashevych, O. (2019). Why “Permissioned” and “Private” are not Blockchains. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3496468

Kosmarski, A. (2020). Blockchain Adoption in Academia: Promises and Challenges. *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(4), 117. https://doi.org/10.3390/joitmc6040117

Mavroeidis, V., Vishi, K., D., M., & Jøsang, A. (2018). The Impact of Quantum Computing on Present Cryptography. *International Journal of Advanced Computer Science and Applications*, *9*(3). https://doi.org/10.14569/ijacsa.2018.090354

Mazzei, D., Baldi, G., Fantoni, G., Montelisciani, G., Pitasi, A., Ricci, L., & Rizzello, L. (2020). A Blockchain Tokenizer for Industrial IOT trustless applications. *Future Generation Computer Systems*, *105*, 432–445. https://doi.org/10.1016/j.future.2019.12.020

Mohanta, B. K., Panda, S. S., & Jena, D. (2018). An Overview of Smart Contract and Use Cases in Blockchain Technology. 2018 9th International Conference on Computing, Communication and Networking Technologies (ICCCNT). https://doi.org/10.1109/icccnt.2018.8494045

N. Al-Zaben, M. M. Hassan Onik, J. Yang, N. -Y. Lee and C. -S. Kim, "General Data Protection Regulation Complied Blockchain Architecture for Personally Identifiable Information Management," 2018 International Conference on Computing, Electronics & Communications Engineering (iCCECE), 2018, pp. 77-82, doi: 10.1109/iCCECOME.2018.8658586.

Partridge, C. (2008). The Technical Development of Internet Email. *IEEE Annals of the History of Computing*, *30*(2), 3–29. https://doi.org/10.1109/mahc.2008.32

Quadrans Foundation. (2022). *Quadrans Blockchain Sustainability Report*. https://quadrans.io/content/files/quadrans-report-2022-05-13.pdf

Rooksby, J., & Dimitrov, K. (2019). Trustless education? A blockchain system for university grades[1]. *Ubiquity: The Journal of Pervasive Media*, *6*(1), 83–88. https://doi.org/10.1386/ubiq_00010_1

Salim, S. (2021, January 13). *Blockchain and the era of gaming*. Digitalinformationworld.Com. https://www.digitalinformationworld.com/2021/01/blockchain-and-era-of-gaming.html

Statista. (2022, May 23). *Use cases for blockchain technology in organizations worldwide 2021*. https://www.statista.com/statistics/878732/worldwide-use-cases-blockchain-technology/

Tapscott, D., & Tapscott, A. (2016). *Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World*. Portfolio.

Taylor, P. J., Dargahi, T., Dehghantanha, A., Parizi, R. M., & Choo, K. K. R. (2020). A systematic literature review of blockchain cyber security. Digital Communications and Networks, 6(2), 147–156. https://doi.org/10.1016/j.dcan.2019.01.005

Torky, M., & Hassanein, A. E. (2020a). Integrating blockchain and the internet of things in precision agriculture: Analysis, opportunities, and challenges. *Computers and Electronics in Agriculture*, *178*, 105476. https://doi.org/10.1016/j.compag.2020.105476

Torky, M., & Hassanein, A. E. (2020b). Integrating blockchain and the internet of things in precision agriculture: Analysis, opportunities, and challenges. *Computers and Electronics in Agriculture*, *178*, 105476. https://doi.org/10.1016/j.compag.2020.105476

Zarrin, J., Wen Phang, H., Babu Saheer, L., & Zarrin, B. (2021). Blockchain for decentralization of internet: prospects, trends, and challenges. Cluster Computing, 24(4), 2841–2866. https://doi.org/10.1007/s10586-021-03301-8

Zhou, X., Yan, J., Zhu, J., & Cai, P. (2013). Survey of energy consumption and energy conservation measures for colleges and universities in Guangdong province. *Energy and Buildings*, *66*, 112–118. https://doi.org/10.1016/j.enbuild.2013.07.055

Zwitter, A., & Hazenberg, J. (2020). Decentralized Network Governance: Blockchain Technology and the Future of Regulation. *Frontiers in Blockchain*, *3*. https://doi.org/10.3389/fbloc.2020.00012

7. Appendices

7.1 Appendix A - Results of Quadrans report

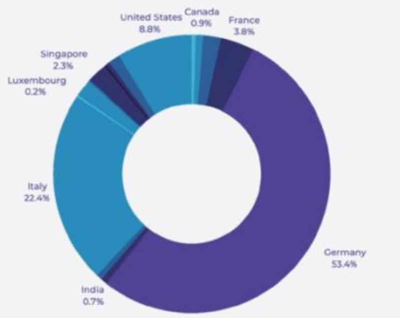


Immagine (1):
Quadrans Node distribution

Mainnet energy consumpion per year (KW)	Mainnet Kg CO2 x year	Energy per transaction considering 60K TPS (W)	gCO2 x Transaction (Considering 60K TPS)
2111,23	645,82	0.00001357	0.00000412

Figure 4 - Quadrans Node Distribution

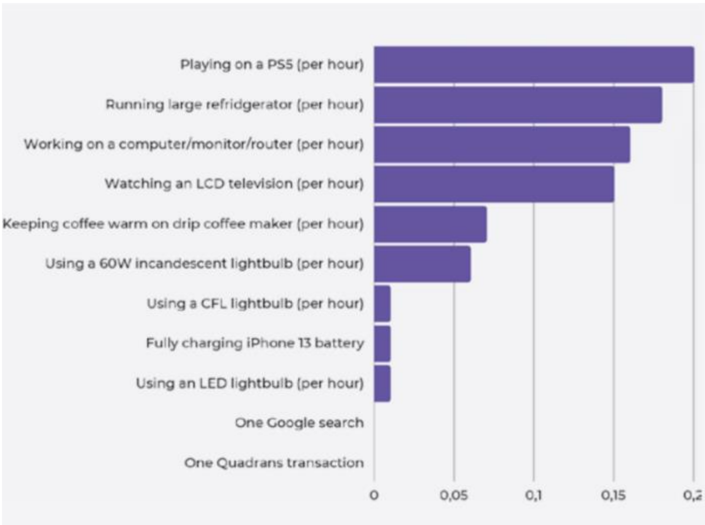


Figure 5 - Quadrans Transaction Energy Consumption Comparison 2

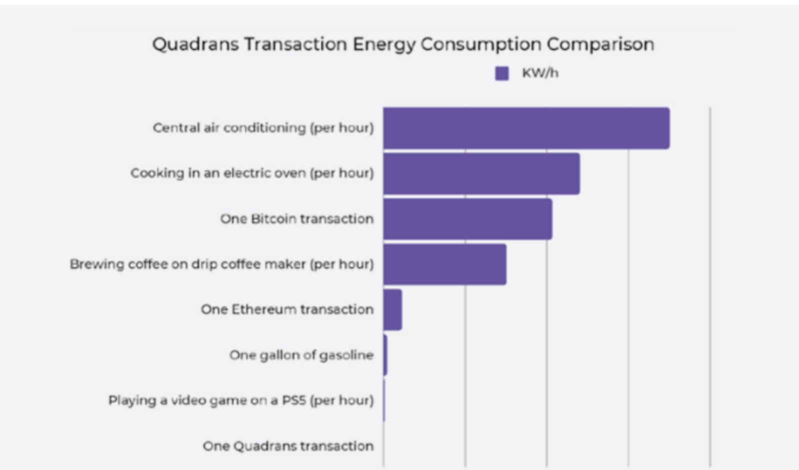


Figure 6 - Quadrans Transaction Energy Consumption Comparison 2

Comparision (w/ source)	Watts	Kilowatthour	Equivalent Quadrans transactions (*1000)
Average US household (per year)		10649	801413301,2
One Google search		0,0003	22,57714249
One Quadrans transaction	0,000013	0,00	1
Using an LED lightbulb (per hour)	10	0,01	752,5714163
Fully charging iPhone 13 battery		0,01241	933,9411277
Using a CFL lightbulb (per hour)	13	0,013	978,3428412
Working on a computer/monitor/router (per hour)	158	0,158	11890,62838
Using a 60W incandescent lightbulb (per hour)	60	0,06	4515,428498
Keeping coffee warm on drip coffee maker (per hour)	70	0,07	5267,999914
Watching an LCD television (per hour)	150	0,15	11288,57124
Playing a video game on a PS5 (per hour)	197	0,197	14825,6569
Running large refridgerator (per hour)	180	0,18	13546,28549
Brewing coffee on drip coffee maker (per hour)	1,5	1500	112885712,4
Cooking in an electric oven (per hour)	2,4	2400	180617139,9
Central air conditioning (per hour)	3,5	3500	263399995,7
One gallon of gasoline		33,7	2536165,673

Figure 7 - Quadrans Transaction Energy Consumption Comparison 3

Comparision (w/ source)	Watts	Kilowatthour	Equivalent Quadrans transactions (*1000)
One Ethereum transaction		216	16255542,59
One Bitcoin transaction		2059	154954454,6

Figure 8 - Quadrans Transaction Energy Consumption Comparison 4

7.2 Appendix B – Survey

Blockchain in universities – too early or too late?

Welcome! This is a survey for my Bachelor Thesis at Maastricht University.

In foremost, I want to thank you for deciding to participate to this study on blockchain's implementation in the university field. Since this questionare requires a **moderate level of expertise in the field of modern technology**, only a part of you can contribute to this research. If you are part of this group, this survey should take you more than **10min** to complete. My research focuses the readiness of universities to adopt innovative technologies like blockchain for notarization proposes, cybersecurity and more! The significance of raising such awareness, in industries more than anywhere else, can help grasp the full potential of this technology to be prepared to embrace the new era of decentralized information.

All submitted responses will be treated **confidentially** and **anonymously**. I kindly ask you to read the following questions **carefully** and respond in a **sincere** way, considering your **knowledge in the field**.

1. Are you experienced in blockchain technology, modern cryptography, or digital innovation? Do you feel confident answering questions that tackle these topics? **YES / NO**
   - ☐ I am currently working at a company that deals with one of these topics as its major focus
   - ☐ I studied blockchain technology, modern cryptography, or digital innovation in my Master's or Ph.D. studies.

From now on, the responses will be based on this scale:

Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
1	2	3	4	5

	2. Generally speaking, current IT systems used in universities can be enhanced by implementing blockchain technology.	**1 2 3 4 5**
Cybersecurity	3. Considering new leaps in computational power, namely quantum computing and more, blockchain's encrypting capabilities and structure has the potential to withstand such power.	**1 2 3 4 5**
Cybersecurity	4. The division of data packages in multiple nodes across a blockchain network is secure and does not compromise the existence and immutability of the data.	**1 2 3 4 5**
Cybersecurity	5. Blockchain technology will represent a new standard in cybersecurity.	**1 2 3 4 5**
Cybersecurity	6. If implemented correctly, the chances of suffering from a ransomware attack is close to zero with blockchain.	**1 2 3 4 5**
Sustainability	7. Without considering the primarily current applied first versions of the blockchain (Bitcoin or Ethereum), the infrastructure of blockchain as we know it today can be more sustainable than current I.T. systems considering all costs needed (maintenance, hacks, etc.).	**1 2 3 4 5**
Sustainability	8. A decentralized public blockchain can be substantially less energy-consuming than a google search.	**1 2 3 4 5**
Notarization	9. Personal data is currently stored in traditional-fashioned systems that often even pursue human paths of notarization. Blockchain would be a more suitable option for these tasks.	**1 2 3 4 5**

Figure 9 - Survery page 1

Notarization	10. The capability of smart contracts that blockchain technology offers can be applied to multiple use cases that require verification processes at universities, such as exam validation or ECTS accreditations	**1 2 3 4 5**
Insufficient knowledge	11. In your experience, people working in the industry of technological change often don't know the capabilities of blockchain	**1 2 3 4 5**
	12. Blockchain is poor across individuals in academia	**1 2 3 4 5**
	13. The fact that the technology is based on complex mathematics makes its comprehension more challenging and therefore applying such technology more difficult	**1 2 3 4 5**
	14. There is no evidence that blockchain is being used in universities	**1 2 3 4 5**
Incomplete data regulations	15. If you are still paying attention to responding to these questions correctly, please insert "2" for this question.	**1 2 3 4 5**
	16. Considering data regulations mentioned in the GDPR, blockchain's core aspect of immutability is in contradicts the "right to be forgotten"	**1 2 3 4 5**
	17. Current data regulations inhibit the adoption of BC in universities specifically, since they operate close to the ministry of education	**1 2 3 4 5**
Immaturity of technology	18. I consider the technology as immature to be used for any puropose yet, specifically for educational institutions	**1 2 3 4 5**

19. What is your sex?
    - ☐ Male
    - ☐ Female
20. What is your age?
    - ☐ Under 20
    - ☐ 20-26 years
    - ☐ 27-40 years
    - ☐ 41-55 years
    - ☐ 56+ years
21. Which of the following occupations are closest to yours?
    - ☐ Modern cryptographer engineer
    - ☐ Blockchain expert (or coordinator of a study program containing BC-knowledge)
    - ☐ Blockchain engineer
    - ☐ Executive for digital innovation
    - ☐ Computer engineer
    - ☐ Data Scientist
    - ☐ B.I -analyst
    - ☐ Other

Thank you again for participating, you answers are valuable and will be considered respectively!

Figure 10 - Survery page 2

APPENDIX 2: OFFICIAL STATEMENT OF ORIGINAL BACHELOR THESIS

By signing this statement, I hereby acknowledge the submitted thesis (hereafter mentioned as "product"), titled:

Examining the impact of the adoption of blockchain technology in universities…

to be produced independently by me, without external help.

Wherever I paraphrase or cite literally, a reference to the original source (journal, book, report, internet, etc.) is given.

By signing this statement, I explicitly declare that I am aware of the fraud sanctions as stated in the Education and Examination Regulations (EERs) of the SBE.

Place: Maastricht

Date: 18th June 2022

First and last name: Riccardo Marciano

Study programme: Economics and Business Economics - IN specialization

EBT Code (i.e., code of the BSc thesis course you registered for): EBT0004

ID number: i6216460

Signature:

Figure 11 - Official statement of original Bachelor Thesis