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Blockchain Ethics

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Abstract: There is no question about the innovation force and the economic potential of blockchain technology. As the basis for new currencies, financial services, and smart contracts, blockchain technology can be seen as the fifth disruptive computing paradigm, after mainframes, personal computers, the Internet, and mobile devices. However, there are questions about its ethical implications, which have the potential to also impact the economic success of blockchain technology. This article aims to provide ethical guidance on blockchain technology. In order to reach this goal, the focus of the ethical analysis will first concentrate on the unique characteristics of blockchain technology compared to other technology-based innovations. The unique nucleus of blockchain technology can be defined as a move from the trust in people to a trust in math, as a move from an internet of information to an internet of value, or—as I would propose—a shift from an intermediated network to an immediate network. Second, the ethical opportunities (e.g., transparency, participation, global access to services) and risks (e.g., ecological impact, lack of legal monitoring and enforcement) associated with this unique nucleus of blockchain technology will be discussed. Third, an outlook on possible concrete solutions will be provided.

Keywords: blockchain technology; ethics; intermediated network; intermediaries; immediate network; transparency; participation; access; ecological impact; law

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1. Blockchain Technology—From an Intermediated Network to an Immediate Network

The innovation force and the economic potential of blockchain technology are enormous. "In the last decade, the dependency of our society on decentralized intelligent systems has dramatically escalated" [1]. Blockchain technology is the basis for new currencies and financial services as well as for smart contracts. After mainframes, personal computers, the Internet, and mobile devices, blockchain technology can be seen as the fifth disruptive computing paradigm [2,3].

At the same time, there are ethical questions which have arisen in the context of blockchain technology, requiring more attention due to their complexity [4]. Ethical issues like security and equity have gained attention [5]. The question has been posed as to whether there is a need for a "blockchain code of conduct" [6]. This article tries to identify the ethical dimension of blockchain technology and to discuss these ethical aspects.

The timing of this endeavor seems to be apropos because blockchain technology is still an emerging technology. Maybe its further design and application could happen in an ethically informed manner.

Before addressing these ethical questions, a conceptual understanding of what blockchain technology stands for is necessary. "It consists of a permanent, distributed, digital ledger, resistant to tampering and carried out collectively by all the nodes of the system. The formidable innovation introduced by this technology is that the network is open and participants do not need to know or to trust each other to interact: the electronic transactions can be automatically verified and recorded by the nodes of the network through cryptographic algorithms, without human intervention, central authority, point of control

or third party (e.g., governments, banks, financial institutions or other organizations). Even if some nodes are unreliable, dishonest, or malicious, the network is able to correctly verify the transactions and protect the ledger from tampering through a mathematical mechanism called *proof-of-work*, which makes human intervention or controlling authority unnecessary" [7].

If one wants to transact on the blockchain, one must have a wallet containing a public key and a private key [8]. The public key consists of a kind of email address on the blockchain which allows others to transact with that address. The private key utilizes a password and provides the user with the possibility to transact from any address to which they have the private key. So, one must possess a private key for transactions on a blockchain, which enhances the security of blockchain technology. These keys are inherently coupled, which is what gives the system the security that it has. As one loses access to a blockchain by losing one's private key, digital wallets are used to store the private key and streamline transactions [9]. These transactions take place and are stored on the decentralized blockchain, not on the public or private key.

Blockchain technology thus includes "a shift from trusting people to trusting math" [10] "by coding the normative values and technical properties into its basic infrastructure" [11,12]: "esta confianza fundada en un diseño tecnológico y capacidades computacionales muy robustas" [13] ("this confidence based on robust technological design and computational capabilities"). Institutional intermediaries providing trust seem to become obsolete. This shift could provide a paradigmatic improvement for science, research, innovation, development, and technology in general by opening up a new horizon of open access academic publishing based on blockchain technology—including, e.g., the scientific discourse of which this article is a part. Why? Because blockchain technology guarantees everyone continuous documentation not belonging to anyone and not being controlled by anyone and access at all times to review cryptographically verified peer-to-peer procedures. It possesses the potential to change the process of science, research, innovation, development, and technology fundamentally, transforming it into to a completely open and transparent process. In this way, blockchain technology respects the right to intellectual property, and in virtue of that, it encourages and motivates free, open, and independent scientific discourse.

Beyond that, blockchain technology can be interpreted from the perspective of another shift—from an internet of information to an internet of value [2]. Although one could argue that value can be broken down to information and therefore this shift should be framed differently, Melanie Swan and Primavera De Filippi adequately highlight "the secure, end-to-end and computationally validated transfer of value (whether it is represented by money, assets, or contractual arrangements) via smart networks" [14,15] as an innovative nucleus of blockchain technology. Therefore, I suggest that the shift should be defined differently, namely *a shift from an intermediated network to an immediate network*. This means that while so far, an intermediated network has been in place where an actor or an institution plays a central role in connecting the nodes of the network and in providing the network, blockchain technology allows the nodes of the network to connect immediately and in a decentralized manner without an intermediary being involved.

The ethical analysis of blockchain technology in this article proceeds within a hermeneutic and fundamental framework of understanding the correlation between ethics and technology in a context partly created by technology as based on reciprocity: both ethics and technology are closely intertwined and contribute to each other on different levels and in several dimensions. This understanding of the close correlation between ethics and technology starts from the premise that ethics is based on "an interaction with technology" because ethical discourse of technology depends on the understanding that technology is "something made" and "not anything given" [16].

This understanding of the correlation between ethics and technology continues by acknowledging that perceiving technological development as a linear process pursuing a well-defined scope would probably not correspond to the present-day theory and reality of technology [17]. Technological innovations are rather often the result of small steps and

represent sometimes random products [18]. "Technology is not ordinarily developed after carefully considering the various possible ramifications. In most cases a new technology is developed because it promises major short-term benefits and is judged not to cause any immediate problems" [19]. In addition, the speed of technological advancement outpacing normative considerations represents another characteristic of the way technology functions. Furthermore, some norms exist by dint of certain technological developments. In addition, the complexity of technological innovation should not be underestimated [20]. Beyond this, ground-breaking ideas in technology and their successful application provoke a concrete impact on ethics, as technology creates value, solutions for societal challenges, and innovation [21]. One would need to go even further by perceiving the impact of technology even on implicit norms, attitudinal orientations, comportment, and even the intangibles of human experience as concrete features of reality. Therefore, technology leads to innovation in the moral dimension, because the ramifications of a technology on society and individuals need to be accounted for in ethics as well [22]. Finally, smart technology is influencing (e.g., by nudging) [23] individual lives at least, if not even the ethical dimension of individual lives [24].

At the same time, ethics contributes to technology, for example by stimulating technological innovation [21], by recognizing technological inventions [21], and by providing ethical guidance [25]. One needs to go even further, stating that ethics belongs to technology. "The idea of scientific knowledge as value-neutral is simply incorrect. Values are intrinsic to the making of science and technology, and they both reflect and transform particular values" [26]. Horizons of meaning and moral ends inform technology in an ethical sense. Beyond that, while the technology community is aware of the legal obligations and legal compliance standards in the development of technology, the community nevertheless strives to respect ethical principles in its work as well, for example displaying honesty, objectivity, independence, impartiality, fairness, and responsibility for future generations. Furthermore, ethics can critically examine the legal obligations and legal compliance standards of the technology community on a regular basis. This should (ideally) lead to a continuous optimization of the legal framework for technology. In addition, ethics can help in the process of agenda-setting in technology by defining the right priorities, but also in adequately framing the sphere of influence and responsibility of technology.

Finally, while technology contributes to the progress of ethics, at the same time, there is an obvious need for ethics in technology in order to be able to conduct the necessary research, discussions, and studies. Technology can be the victim of infringements of its freedom, of attempts to block innovative and creative approaches, and of oppression of ideas, concepts, and discoveries. The reasons for these transgressions can be putative "absolute truths" or the enforcement of economic or political totalitarian power structures. The danger still exists of members of the technology community being prevented from conducting their research freely and independently. Therefore, there is a need for legal and ethical norms supporting and protecting technological progress.

This reciprocal relationship between ethics and technology additionally recognizes the fact that ethics can limit technology. Ethics can pronounce the ethically justifiable position that not everything which is doable is automatically ethically good. This assertion can lead to limitations on technology. Health and safety guidelines, patents, the legal ownership of intellectual property rights, competition policy, consumer protection, and ethical codes of conduct, among others, belong to this category. This impact by ethics can be perceived as blocking and hindering technological innovation. Ethics is challenged more and more by human curiosity striving for new inventions and solutions and by linked substantial economic interests and power as well as connected special interests. Due to the constantly increasing creation of artificial worlds, of "a technological simulacrum of natural life" [27], and the corresponding power and influence of humans, the significance of ethics is growing further.

2. Human Rights-Based Blockchain Technology

In this article, the ethical analysis of blockchain technology will be informed by the ethics of human rights. In other words, human rights will be the guiding ethical point of reference. This leads to the necessity to address the following question: [28] why human rights? Human rights represent a minimal standard that enables survival and living with human dignity for every human [29]. Human rights are neither maximal moral claims nor a higher ethos. This means that they do not overburden technology. Instead, they are achievable for technology. Human rights have a precise focus which can enhance a clear setting of priorities based on the minimal standards which must first be respected. Therefore, human rights can help in the process of agenda setting in technology not only in setting the right priorities, but also in adequately defining the spheres of influence and responsibility [30]. Human rights in their moral dimension [31] can serve as an ethical principle because they are morally justifiable—e.g., based on the principle of vulnerability [29,32]—and represent a universally applicable consensus and not just a regional one [33]. The latter means that no other catalog of norms enjoys the same amount of global acceptance. Human rights enjoy credibility and are a widely respected ethical standard.

In addition, human rights—which can be understood as a value system—do not build upon a particular tradition, culture, religion, worldview, or value system, but rather are common across different traditions, cultures, religions, worldviews, and values systems [34,35]. Human rights not only protect people but also foster diversity and plurality [28]. Consequently, a globalized technology community can be oriented with human rights as an ethical point of reference [36], encountering several traditions, cultures, religions, worldviews, value-systems, and philosophies. While this heterogeneity is, on the one hand, protected by human rights [37], on the other hand, they set out clear limits which need to be respected: human rights protect the essential elements and areas of human existence within traditions, cultures, religions, worldviews, and value systems as well. Therefore, human rights can support technology when acting in favor of human rights, but can lead to tradition-, culture-, religion-, worldview-, and value-system-based challenges [38].

Furthermore, human rights possess a high degree of practice orientation and applicability. Compared with other ethical principles, human rights encompass not only the ethical but also the legal dimension: human rights are legally defined, have a legal framework, are executable and provide some of the formal structure of the implementation of the rule of law, constraining its implementation by means of setting parameters. Of course, it is not the intention with this study to neglect the difficulties of the realization of human rights but to highlight that, compared to purely ethical ideas, the implementation of ethical ideas like human rights which have a legal dimension and legal enforcement mechanisms can be easier.

Beyond this, the individuals involved in technology are protected by human rights in the essential areas and elements of human existence which a human requires for survival and for life as a human. Some of these are of specific significance for technological inquiry, research, development, and application, e.g., the right to freedom [art 2]; the right to freedom of thought, conscience and religion [art 18]; the right to freedom of opinion and expression [art 19]; the right to freedom of peaceful assembly and association [art 20]; the right freely to participate in the cultural life of the community, to enjoy the arts and to share in scientific advancement and its benefits [art 27, 1]; and the right to the protection of the moral and material interests resulting from any scientific, literary or artistic production of which he is the author [art 27, 2], as set out in the Universal Declaration of Human Rights in 1948.

Limits to one's own human rights are, firstly, in the case of a specific human right, the other specific human rights following the principle of indivisibility. This principle defines that all human rights must go hand in hand. This means that the entire catalog of human rights needs to be respected. Therefore, every human right must be implemented optimally and in a way that accords with all other human rights being implemented optimally at

the same time. Secondly, limits to one's own human rights are the human rights of all other individuals. For example, one's own right to freedom goes only so far as it can go hand in hand with the right to freedom of all other human beings. Both limits lead also to corresponding duties for a rights-holder, which is the reason why every right-holder is a duty-bearer as well [39].

Following the guidance of human rights as an ethical point of reference allows one to design, develop, produce, and use human rights-based blockchain technology.

3. Ethical Opportunities of Blockchain Technology

3.1. Democratic Potential

Looking at blockchain technology from an ethical standpoint informed by the ethics of human rights, including the human right to political participation and taking into account one main characteristic of blockchain technology, namely decentralization ("'[d]ecentralization' describes conditions under which the actions of many agents cohere, and are effective despite the fact that they do not rely on reducing the number of people whose will counts to direct effective action" [40]), it is possible to identify—especially with human rights as the ethical point of reference but only under the condition of respect for the state and for the rule of law—the democratic potential that blockchain technology represents as an ethically positive element of this technology. For a democratic system, blockchain technology could provide censorship-resistant organizational models and a decentralized repository for identity verification. Blockchain technology could be used for voting as well [41]. Furthermore, blockchain technology could enable state authorities to become more efficient and effective in providing their services by relying on decentralized self-evolving digitalization [42].

In addition, blockchain technology could help to overcome challenges arising for democracy due to a lack of integrity among political leaders and decision-makers. By, for example, documenting both the promises of election campaigns and their realization to ensure the consistency of political positions defended by politicians, it could enable trustworthy and content-based political representation. Beyond this, blockchain technology could open up a horizon of transparency of influence by documenting the financial support of politicians, of political parties, and of political campaigns [43]. Therefore, trustworthy and content-based political representation as well as transparency of influence serve as motivating factors for the political participation of citizens. This impact is even increased by the possibility that the technology is open for being shaped by the participating entities [44].

Finally, blockchain technology can be categorized—within the framework by Langdon Winner [45]—as belonging to "inherently political technologies, man-made systems that appear to require, or to be strongly compatible with, particular kinds of political relationships" [45]. Due to its decentralized nature, blockchain technology calls for a democratic system rather than for a repressive autocracy. To illustrate this aspect further, contrariwise, the nuclear bomb "as it exists at all, its lethal properties demand that it be controlled by a centralized, rigidly hierarchical chain of command closed to all influences that might make its working unpredictable. The internal system of the bomb must be authoritarian" [45].

A condition for the realization of these democratic opportunities of blockchain technology and due to the fact that "blockchain technologies (are) not merely a technical matter, but that it strongly relates to the ways in which we normatively construct, or rather configure our social world" [46], there is a necessity to "explore how we can implement them in a way that empowers people but that also leaves room for mitigating the potential dangers they bring about. This will require investigating how the governance of the design and use of these technologies can be improved, for instance by looking at ways in which the design process can be organized in a more democratic way" [46].

The implementation of this democratic potential of blockchain technology still needs to be pursued and realized.

3.2. Transparency, Verifiability, Immutability, and Traceability

Transparency—not only in the political sphere—represents another positive aspect of blockchain technology [47] from an ethical standpoint, informed by the ethics of human rights including the human right to freedom and autonomy. If used as an open-source code, blockchain technology offers everyone access at any time to review cryptographically verified peer-to-peer procedures—instant "real-time transparency" [48]. Therefore, blockchain technology offers verifiability: "Transactions are immediately auditable in real time. As an immutable and sequenced digital ledger, a Blockchain allows the complete record of transactions to be directly verified" [49]. As this open-source code does not belong to anyone and is not controlled by anyone [7], blockchain technology fosters transparency by excluding undisclosed influences or censorship by the owner or by the controlling entity. In addition, it enfolds because all nodes simultaneously and constantly store the data and provide proper redundancy [7]. Both transparency and immutability [2,14] lead to the traceability provided by blockchain technology, promoting human rights as an ethical point of reference as they allow for identifying the subjects of a decision or an action. Blockchain technology could be applied in this way, for example, in the management of supply chains [42,50], in model monitoring during the development of "artificial intelligence" [51]—more adequately referred to as data-based systems (DS) [4]—but also in the fight against human rights violations in supply chains [52–54].

3.3. Economic Potential

Blockchain technology could provide—among other services—access to banking and to financial services for about two billion people without a bank account [55]. Linked with this economic potential [42,56–58] is the ethically positive aspect from a human rights perspective. One can argue that having access to minimum basic financial services (money, a minimum credit amount, a savings account, and a low-cost money-transfer option) contributes to the respect and realization of human rights. The main reason for this position is the significant role that financial resources play in the daily life of humans, allow several aims to be achieved, including essential elements and areas of human existence which a human requires for survival and for life as a human and which are protected by human rights. In addition, as developments of the financial markets have an impact on the daily life of everyone, especially the impoverished, everyone should at least have the possibility to participate in the financial markets. Beyond this, the access to certain financial services could be an instrument to overcome illegitimate global inequality and would fulfill the "gap-closing-principle": "Financial institutions and finance-systems contribute to global justice if they contribute to the realization of human rights of all humans and if they contribute to the closing of the gap between poor and rich" [59]. While maintaining in the greatest possible way the economic rationale of pursuing one's own particular interest, the "gap-closing-principle" introduces the perspective of the poor only as a corrective of the "ad infinitum" of the pursuit of one's own particular interest(s).

Beyond this, cryptocurrencies could provide financial security in contexts with unstable local currencies, which is not only of economic but also of ethical relevance by contributing to the realization of human rights as an ethical point of reference.

Finally, with its potential role in land titling and property transactions to whom a significant role in economic development can be attributed [60], blockchain technology could contribute to economic development, especially in developing contexts—again of significance from a human rights perspective [61].

There exists the above-mentioned potential to contribute to the creation of more global equality by offering more people access to financial services and markets. By taking into consideration the impact of blockchain technology on the economy so far, another scenario comes into play, namely that blockchain technology runs the risk of serving as a vehicle contributing to widening the gap between rich and poor. This could happen due to the lack of access to blockchain technology and would strengthen already established privileged positions. This would mean also that fewer people are directly involved economically and

socially in a more efficient and more effective value-added chain [62]. On the one hand, this development means that more value will be created. On the other hand, fewer people will contribute directly to the value-added chain and benefit from this added value. The main challenge from an ethical perspective is therefore not a lack of financial means, because more efficient and more productive value-added chains based on blockchain technology can lead to an increase in that regard, but rather the question of human rights. At stake at the center of these concerns is the distribution of the added value which is created. This is a question of social integration, as fewer people are involved in the value-added chain based on blockchain technology—a concern which represents the core consequence of digital transformation in general [63].

3.4. Health Impact

Blockchain technology can support the realization of the human right to health by providing the possibility of decentralized storage of and access to personal health records (also consisting of genomic data), which would allow personalized, more independent, precise, efficient, and effective health care. This innovative attempt to contribute to the realization of the human right to health must of course respect the human dignity of all humans (and therefore distance itself from instrumentalizing or objectivizing humans); decentralized storage of and access to the personal health record must respect the human right to privacy, based on the principle of the indivisibility of human rights [64], must honor data protection and the right to informational autonomy, must overcome the significant challenges of big data "volume—velocity—variety—veracity" [65], and must address the risk of big data being a source of systematic discrimination.

4. Ethical Risks of Blockchain Technology

4.1. Ecological Impact

Aiming at the ethical point of reference of human rights—more specifically, the right to life, the right to health, work-related rights, and the right to an adequate standard of living, including the right to housing, food, and water [66]—the enormous energy consumption of the proof of work consensus method [67] is ethically problematic [68]. In the case of Bitcoin, for example, in order to reach the validity of a proof of work, a billion watts is estimated to be necessary [69]. In other words, "currently, global power demand from cryptocurrency mining hovers at about 22 terawatt hours (TWh), but increasing demand means consumption could surge in 2018 to 125–140TWh—a full 0.6% of world consumption. Although that level is still far from material to global utility power demand, it's worth noting that 0.6% is roughly the electric consumption of Argentina in a typical year" [68].

Attempts to resolve this ecological problem of blockchain technology consist of making "mining" greener or circumventing the mining process. "User lock up quantities of cryptocurrency for periods of time, which secures blockchain used by that currency. In return, they receive cryptocurrency rewards, as if they had mined cryptocurrencies themselves" [70]. As this approach is still dependent on "mining" in the first place, it does not seem to address the ecological problems of blockchain technology. "Some people wonder if crypto-currencies will disrupt the financial system, while others wonder if they will break the environment in the process" [70].

Beyond this, layer 2 solutions like the lightning network could be part of a solution regarding the ecological impact as they do not ordinarily have the same energy requirements but facilitate a significant increase in the number of transactions. Moreover, proper planning proof of work would benefit the environment by utilizing excess energy such as during non-peak times or flaring.

4.2. Money Laundry and Financing International Crime and Terrorism

"If blockchain and subsequently cryptocurrencies are anonymous then what is preventing malicious or questionable use/manipulation?" [71]. Represented or utilized as a technological basis for cryptocurrencies, blockchain technology enables an "anonymous

currency" [72]. This application creates the ethical problem—which becomes obvious while orienting oneself towards the ethical point of reference of human rights—of providing a means of laundering money with impunity [73].

Cryptocurrencies—relying on blockchain technology—are also used for funding international crime and terrorism [74]—again, ethically unacceptable based on the ethical point of reference of human rights [75,76].

A criticism arises together with some doubts questioning the positive impact provided by blockchain technology, namely economically empowering people, and the ethically positive characteristics of blockchain technology mentioned above, namely transparency, immutability, and traceability. If these exist, then countermeasures against money laundering and financing international crime and terrorism should be easily implementable, enforceable, and successful. In order to build an atmosphere of liability and accountability, subjects of a decision or an action should be identifiable. Although this necessity of identification is criticized [77], in order to make someone responsible or hold someone accountable from a normative standpoint, there seems to be no other option. This accountability is necessary in order to guarantee the same legal and ethical principles, norms and standards offline as well as online, in the digital sphere, and on the blockchain. At the same time, complexity cannot serve as an excuse liberating one from legal or ethical obligations and responsibilities because ethical and legal norms keep their validity even in complex situations and contexts.

There is a need for further research and innovation in the area of blockchain technology, striving for "ethically guided cryptocurrency systems whose behaviors are informed by human ethical values" [78] and for "a successfully functioning 'cryptocurrency with a conscience'" [78].

4.3. Human Rights Violating Excavation of Resources and Production of Technology

The gathering of natural resources and means of production poses additional risks of human rights violations. As the ways in which natural resources for the production of technologies and technology-based applications are obtained involve excavation and exploitation, and as the ways in which technologies and technology-based applications are produced involve modern slavery and slavery-like working conditions, an increase in the demand for these natural resources for use in blockchain technology will also increase these human rights violations. The increased demand for natural resources fueling the dissemination of blockchain technology calls for optimizing the implementation of already existing human rights obligations of states and the private sector in this area [54].

4.4. Right to Privacy

Against the background of the principle of the indivisibility of human rights, the right to privacy is still discussed separately due the essential relevance of the technology-based risks around privacy. On the one hand, blockchain technology generates a solution on how digitalization and digital transformation can be pursued without violating the right to privacy by providing the technological basis for an independence of digital activity from technology firms harvesting data and offering them for sale to companies. Blockchain technology allows one to be online without being surveilled, monitored, or analyzed, without becoming a product, which then is sold to others without informed consent. On the other hand, blockchain technology consists of contents being publicly viewable and stored on a very large number of computing nodes. The contents are permanently stored on the blockchain. They cannot be deleted and cannot be changed even if errors occur [79].

Blockchain technology remains a technology-based infrastructure, which of course has an origin, an owner, and a provider. "Technological considerations weigh heavily on the assessment of the exact degree of anonymity" [75]. This means that, at the same time, it is technically not impossible that someone would be able to gain access to the online activity of an individual.

5. Concluding Remarks: The Ambiguity of Blockchain Technology and the Relevance of More Ethical Reflection

In this article, guided by human rights as an ethical point of reference, I show that blockchain technology can serve ethically good purposes and can lead to ethically bad consequences, depending on the concrete applications and solutions. The ethical positives as well as the ethical negatives can be viewed at the individual, organizational, and societal levels [80,81]. At the same time, ethical research is facing challenges regarding the ambivalence that even an ethically legitimate application based on blockchain technology can have, displaying both ethically legitimate and ethically illegitimate sides. Beyond this, also in the area of blockchain technology, ethics has to deal with the "dual use" problem.

Finally, blockchain technology, as an immediate network, not an intermediated network, has implications for its ethical assessment with human rights as the ethical point of reference. Due to the lack of intermediaries (as a unique feature of blockchain technology), the responsibility for the blockchain lies in the hands of the immediately connected participating entities because there is not any intermediary institution carrying the burden of responsibility for them.

This outlined ethical complexity of blockchain technology calls for ethical guidance in order to be able to benefit from the potential and address the challenges of blockchain technology. This article tries to contribute to mastering this challenge by addressing some of the ethical questions which arise in the context of blockchain technology and by providing some ethical guidance in the area of blockchain technology, both by transparently introducing and by concretely applying human rights as ethical points of reference. Further research contributions within specific applied domains of blockchain technology are necessary [82,83], e.g., blockchain ethics in healthcare [84,85], blockchain ethics in organizations improving the work environment [86], and blockchain ethics in accounting [87]. This need is based on a fundamental principle serving as a horizon of understanding: the ethical responsibility of humans for blockchain technology cannot be delegated to blockchain technology itself due to the moral capability of humans. Even though humans are more and more excluded from value-added chains, humans remain the decisive and leading actors for these processes due to their moral capability. Blockchain technology-based applications can follow and implement heteronomously predefined norms [88], but they lack autonomy, freedom, and conscience [89], and they do not possess the moral capability to define autonomously moral norms which are universalizable [90]. For the same reason, one would deny technological systems autonomy and moral capability [91], even if they pretend to decide and to act as if they were moral actors [88]. It is up to humans to provide guidance to blockchain technology, and to define the speed and outreach of its progress [92], by setting ethical principles and norms and by remaining liable for the decisions and actions of blockchain technology-based applications because of their moral capability. Part of this moral capability is to include ethical principles and categories in the production, design, programming, and use of blockchain technology [93], and to interact continuously with technological progress [94]. This ethical responsibility of humans is even growing due to the constantly increasing creation of artificial worlds and the corresponding power and influence of humans. "If there is one thing the great institutions of the modern world do not do, it is to provide meaning. Science tells us how but not why. Technology gives us power but cannot guide us as to how to use that power. The market gives us choices but leaves us uninstructed as to how to make those choices. The liberal democratic state gives us freedom to live as we choose but refuses, on principle, to guide us on how to choose" [95]. Humans need to live up to the responsibility corresponding to that freedom and decide how to create, design, produce, use and not use blockchain technology based on ethical grounds.

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