Boosting Sustainable Digital Education: Blockchain Technology in Education.

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Abstract*— This paper is devoted to digital technologies used in the process of education at HEI´s. There are presented research results coming out from a study aimed on investigating blockchain technology and its implementation in educational sector. The term "blockchain" was not widely known a few years ago and was mainly related with its usage in the financial sector, above all with cryptocurrencies. However, recently we can observe that blockchain technology gain more attention and its application as well in other areas. The education sector adjusted its processes to digitization quickly above all during the pandemic period. In our research, we have been keen on asking a question and finding answer, if blockchain technology have applications as well in education. We based our study on literature review and data from a survey, where online questionnaire was used. The findings discover awareness of blockchain technology, aspects and areas suitable for implementing blockchain technology in educational sector. Blockchain as a decentralized ledger can be perceived as a secure and reliable place with its clear applications as well in educational processes at HEI´s.

Index Terms— ***Blockchain, blockchain technology, digital education, new technologies, sustainable education.***

I. INTRODUCTION

Current research and studies aiming on blockchain has been focused on opportunities of this new technology provided in various applications to take advantage of the main features such as decentralization, persistency, anonymity, and auditability [1]. Anyway, recently we can observe that blockchain technology gain more attention and its application as well in other fields as for example in capital markets [2], [3], in food [4], [5] and agricultural supply chains [6] , [7], [8], [9], healthcare [10], [11], [12], information systems, wireless networks, Internet of Things [13], governmental services [11], [14], and military/defense [1] or intelligent transportation [9], [15]. Indeed, thanks to its ability to increase fairness and transparency and to help organizations save money and time, this technology is influencing a wide range of industries [15], ranging from basic individual entertainment activities to the management of critical and sensitive affairs of governments and states [11].

II. LITERATURE REVIEW

This section is devoted to a literature review of blockchain technology in relation to educational sector. Related scientific papers presenting surveys and studies were examined for their ideas and contribution to the knowledge and to uncover research gaps and inconsistencies that could be addressed in future works.

Blockchain was introduced as a new technology and began as a peer-to-peer database for recording Bitcoin cryptocurrency transactions in the year 2008 [16].

This modern technology consists of a chain of blocks that allows to securely store all committed transactions using shared and distributed networks [1], [2], [12], [17]. All transactions are carried out in a decentralized way, removing the need for any mediators to confirm and verify them [1] [3].

Blockchain has some key characteristics [1] such as:

Decentralization: In the blockchain, a transaction can be performed between any two entities/actors without the need for central authentication. As a result, the use of blockchain can dramatically cut server expenses while also alleviating performance constraints at the central server.

Persistency: It is nearly impossible to tamper with the system because each transaction must be validated and recorded in blocks dispersed across the whole network.

Anonymity: With a created address, each user can communicate with the blockchain network. Furthermore, a user could generate a large number of addresses in order to protect his/her identity. It is (worth mentioning that just a few blockchain implementations offer anonymity. The majority of them are pseudonymous).

Auditability: Users can easily check and trace prior records by accessing any node in the distributed network because each transaction is confirmed and stored with a timestamp.

The main objective, as it is said in [18], was to reduce any intermediaries and to allow clients to access their business directly, this is why Blockchain was created as a decentralized network of peer nodes. The main specifics of each entity can be identified as followed [18]:

- *each entity can have copy of the ledger of transactions;*
- *when it obtains agreement from the others in the network, it can create an item to its own repository;*
- *can verify that the ledger it possesses is identical to those throughout the network on a regular basis;*
- *broadcasts to the rest of the network any transaction made by its users.*

Blockchain viewed like distributed database or public ledger stores a list of all digital events or transactions that have occurred and it is fundamentally shared among all participants. Only if the majority of the participating parties decide, a transaction can be valid. Moreover, it is impossible to remove or change data unless with the agreement of all or the majority of the network participants, once it has been confirmed and inputted, it is very easy for anyone to steal a cookie from a cookie jar that is kept in a hidden place than to

steal from a jar that is placed in a market place, where thousands of people are keeping an eye on [3]. The name Blockchain was not given to this technology by chance: A "chain" of separate "blocks" of data is often used to characterize the digital ledger. A new "block" is formed and attached to the "chain" as new data is uploaded to the network. This requires that all nodes update their Blockchain ledgers in order to be identical. Why Blockchain is considered highly safe is due to how these new blocks are formed. Before a new block can be added to the ledger, a majority of nodes must check and certify the legitimacy of the new data.

In the Fig. 1 is shown the blockchain encompassing in blocks. Each of the following blocks includes the preceding block's hash, a timestamp, information regarding the transaction, the information regarding the nonce number intended for the excavating process and any further specifications desired for the practice to work. The changes in a specific block will create a mismatch with the hashes of the subsequent blocks altogether.

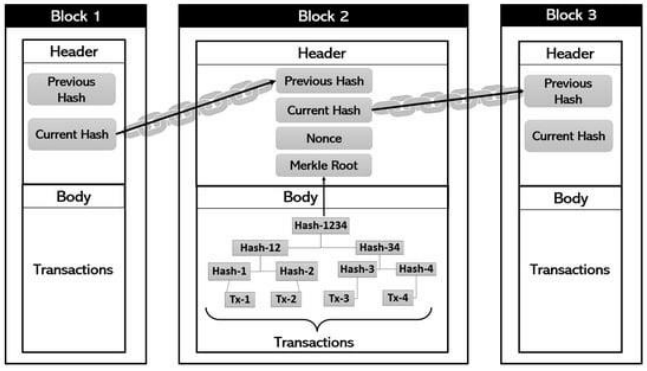

Fig. 1. Blockchain general architecture [1]

A blockchain is a continuously expanding collection of data blocks linked together to form a long chain [19]. As we can see demonstrated in the Figure 1. above that each transaction circulates over the network through blockchain and is authenticated by all compute blocks. The capability to retain a steady viewpoint and consensus between the contributors is the main characteristic of a blockchain, even if a few of them may not be authentic and truthful [1].

This network of connected data blocks represents a distributed ledger that is disseminated over a peer-to-peer network [16]. A distributed ledger contains a collection of digital data that are synced, replicated, distributed, and shared through a peer-to-peer network. Each device linked to the network maintains the latest version of the common ledger, i.e., each peer in the network has a copy of the ledger that is identical to the other. The ledger is mainly characterized by its safety, and the database can be expanded only by the addition of new blocks to the chain. Blockchain technology can find solutions by means of numerous algorithms that are kept in the ledger and are used to detect faults. It also can be determined in which block the error happened in.

Changes to records that have already been registered to the chain are computationally impossible. As a result, a primary benefit of the described distributed ledger is its decentralized nature. The main advantage of this distributed ledger is the lack of any central authority [16], [20].

Some more interesting aspects, benefits, and significance of blockchain were mentioned in the work of [21]:

Networked existence: At the same moment, different users (nodes) on the blockchain network store the same blockchain data. Even if one node fails or loses data, other nodes in the network have a copy of the blockchain and can continue to update it. The blockchain can be recopied from other nodes. This feature guards against data loss and record tampering.

Decentralized nature: Blockchain's decentralized nature eliminates the need for central authority and middlemen, making it more ideal for applications. Blockchain enables systems to be self-contained and devoid of the hazards that come with relying on middlemen and central authorities. Private blockchains, on the other hand, can be partially or totally centralized while still benefiting from the other blockchain features.

Data security and integrity: Blockchain is secure in the sense that any changes to data in any block are discovered by a change in the block hash, which differs from the previously recorded hash in the next block. To be successful, a malicious user must change the block data for all computers on the network, which is essentially impossible in a large network. As a result, data on blockchain is protected against alteration in this regard.

Traceability and transparency: Because blockchain records are time-stamped and saved on all complete nodes on the network, everyone can check and see all activity and transactions. All of a node's activity and transactions can be tracked if its address is known. Blockchain becomes visible and traceable as a result of this. It's also a useful platform for auditing and public services because it's suitable for fraud detection.

Efficiency: Because middleman subsystems are removed, blockchain allows systems to work autonomously with greater efficiency. This is one of the advantages that many companies and countries are hoping to obtain from blockchain technology.

Verifiability: The legitimacy of a record may be checked thanks to blockchain's encryption. This may be difficult to do in other databases since it necessitates cryptographic technologies such as blockchain's digital signature.

Interoperability: Blockchain provides a secure data sharing platform that allows separate parties to share the same data and synchronize their services.

Cost savings: Using blockchain saves a lot of money because it eliminates the need for intermediary systems. Banks might save billions of US dollars each year if they used blockchain efficiently. These savings are one of the reasons why some banks and businesses seek to integrate blockchain into their systems.

Blockchain was originally employed in cryptocurrencies, however nowadays there are numerous applications today. To be more specific, the use of blockchain was introduced in [1] for example smart contracts (utilized for delivering a variety of services to corporations, governments, organizations, and the general public, including financial, medical, games, wallet, voting, libraries, and other services), healthcare management (used for reducing of data inconsistency, elimination of duplicate information that can be involved in documents; so their storage on the blockchain for the purposes of sharing, accessibility, security, cost reduction,

and traceability can eliminate patients' inability to recognize and control their own records), insurance businesses (try to prevent fraud by putting insurance data on the blockchain while also allowing data sharing and interoperability across insurers), banking and finance (with the potential to disrupt the banking and finance industries by experimenting with blockchain in order to improve their systems e.g. to power a variety of services, including online payments and digital assets), IoT industry (with expectations to be autonomous, communicate, and share data without human intervention), decentralized data storage (with the benefits of speed, security, flexibility, and low cost), intellectual properties and document stamping (support of intellectual property and document stamping, which helps to prevent document forgery), digital identity management (traditional identity management is extremely vulnerable to theft, fraud, and loss; with the introduction of blockchain, identities may be managed safely and autonomously without the need for central authorities), project management (standard contract management is inefficient, entails a high level of risk, and results in higher operational expenses and blockchain-based contract management enable to easily track and manage contracts), cybersecurity (to provide secure and permanent records against attackers, network history, configuration, log files, and other network data which are saved on blockchain), asset registry and tokenization (tokens can also be used to represent assets to eliminate fraud and asset theft, asset registries can easily be managed on blockchain in a safe manner).

III. BLOCKCHAIN TECHNOLOGY FOR EDUCATIONAL SECTOR

The education sector is undergoing technological transition. There are numerous challenges with this. Virtual classrooms are taking over from traditional classrooms. The real question is how might blockchain technology help educational institutions and students' study more effectively? [22]

This topic can be answered in a variety of ways, however in this context we can observe three major segments that are followed in order to describe the advantages of blockchain solutions and benefits for educational process [22], [23]:

- *Educational institutions (e.g., universities, start-ups, and non-governmental organizations) that are searching for solutions to improve the efficiency and security of student data storage and management;*
- *Learners who would benefit from more interesting, dependable, and long-term methods of accumulating, attesting, and sharing information;*
- *Employers who want to assess the validity of students' talents and credentials in a trustworthy and secure manner.*

It's worth emphasizing that the application of blockchain in academia is still in its early stages, which has an impact on the availability and quality of research on the subject. The majority of existing solutions employ blockchain as a secure system for validating and distributing personal student data and academic diplomas, along with educational organizations' databases.

It seems that the best way how to explain the blockchain implementation into the educational sector is to divide the interests [22]:

• Enhancing security and efficiency for educational institutions, corporations, and students: Blockchain technology has the potential to protect students' data by ensuring their identification, privacy, and security. As previously stated, blockchain ensures integrity through its hash chain, which provides security and authenticity. Students, for example, cannot change past educational certifications stored on the blockchain. Furthermore, because blockchain does not store data, but rather a hash of it, privacy is assured. Before being stored on the blockchain, the data might be encrypted if desired. As it is mentioned in [24], a variety of blockchain-powered efficiency applications, including record-keeping applications like digital credentials and intellectual properties, simplifying diploma verification, and fast and reliable student payments. Not only do these technologies save money and time for educational institutions, but they also save time and money for companies and individual students.

• Integrating trust and transparency: employers may be assured that job applicants have the required abilities to succeed in the industry since blockchain guarantees that students cannot falsify their grades, degrees, or certifications. Blockchain becomes a ―trust anchor of one truth for credentials as it is said in research [25].

Moreover, this anchor gives job searchers and companies the option to make better matches. In general, because distributed ledger technologies enable learning and protect academic records, they improve interactions between "universities, companies, companies, and their relationships to society" by integrating trust and transparency into skill transactions and sharing procedures.

• Learners' empowerment (self-sovereignty): the data (e.g., credentials, skills taught, etc.) linked with a student's identification is owned by the student, not by a central administration like a university. Students can keep their lifetime learning data (both inside and outside of the classroom), fully own it, and decide who has access to it.

Furthermore, even when students benefit from blockchain "wallets" where they can store and share all of their learning data with various parties (students being complete owners of their identity-related data), they still benefit from the support of their professors, ensuring that they are not alone in their learning journeys. Blockchain can facilitate most important element for educational institutes such as decentralization, immutability, smart contracts, payment registry, security and transparency.

Lushi in [23] showed in his survey that through blockchain can be solved some problems regarding the administration of the transfer of ECTS between universities. He came up with the idea that blockchain like a platform could be used by universities, students and employers to manage ECTS credits and degree certificates. This means a platform, through which the university would issue ECTS credits to students as tokens after successfully passing an exam and consequently a degree certificate after getting the needed number of credits/tokens. Students would be able to show their achievements to their potential employers or to another university through showing

their public key. He saw the main profit of such a platform in issuing ECTS credits to students which would be faster and less complicated; further students wouldn't need to get transcripts of records since they would always have their credits in their wallets and could show these to the interested third parties; student records would be immutable and transparent in blockchain and their personal data would be safer and stored only once. Moreover, exchange semesters would be much easier for students and also for universities (universities would have almost nothing to do since learning agreements would be automatic and students could identify themselves with their self-sovereign identity). Students' credits from partner universities would be automatically calculated and recognized based on smart contracts, through blockchain and smart contracts money and bureaucratic work could be saved, there would be almost no need for personal communication between staff of universities since the complete process would be automated and it means that language barriers would be eliminated (at least for the administration) and university administration would act more as a supervisor of the process than doing the work itself.

IV. Research Methodology and Sampling

From a theoretical perspective, the potential of blockchain technology is recognized throughout the industry. However, very little research has gone beyond conceptual considerations of the benefits offered by blockchain technology for educational sector. This paper attempts to address the lack of insights in research by examining the perception from the perspective of future users of blockchain technology in education, namely students on various study levels.

The study explicitly addresses the following research questions:

RQ1: What is the knowledge of blockchain technology related towards educational sector?

RQ2: What are the aspects influencing implementation of blockchain technology into the educational sector?

RQ3: What are the areas suitable for implementing of blockchain technology into the educational sector?

Regarding data collection, the questionnaires in online format were used as a method to answer the research questions. The research sample consisted of 147 students of business and management studies at bachelor, master and as well doctoral level. Regarding gender structure, the sample consisted of 79 men, 67 women and 1 respondent stated other type of gender without specification.

Data was collected from September until November 2022.

V. Results and Discussion

This section provides the shared benefits of the blockchain technology application for the educational sector. The results and discussion section are deliberated in the following section.

For answering the research question of revealing recent knowledge and for more comprehensive understanding of the blockchain technology by future managers, the analysis of gained data from written questionnaires were undertaken. The obtained research results were analyzed by means of descriptive statistics and content analysis of qualitative data gained from open questions.

In the following figures are introduced and visualized the outcomes of data analysis.

Based on the research results we can see that our respondents are familiar with the concept of the blockchain, because just two of them have never heard about this type of technology. From the gained data we can see that awareness of this technology has been systematically increased since 2014 when some of them have stated to hear about this technology for a first time.

Further, our intention was to explore what kind of knowledge related to this technology our respondents possess. Their answers are visualized in the Fig. 2.

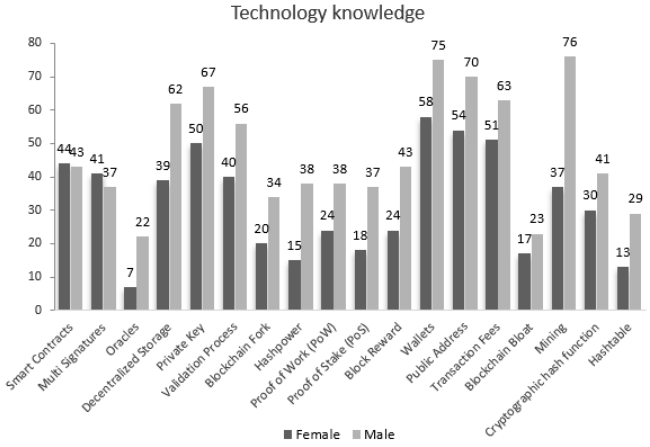

Fig. 2. Respondents´ knowledge towards blockchain technology (Source: own research)

As shown in the Fig. 2, we can see that the possessed knowledge in the context of blockchain technology is generally very good. There are no areas connected to the blockchain technology which would be totally unknown for our respondents. The most respondents´ associations in this context were related with digital wallet (133 positive responses), followed by public address (124 responses), private key (117 responses), transaction fees (114 responses) and mining (113 responses). On the other hand, the least awareness was identified with the items like decentralized storage (29 responses), blockchain bloat (40 responses), hashtable (42 responses) or hashpower (53 responses). We discovered as well contrasts in answers based on respondents´ gender. The most significant discrepancies were identified by possessed knowledge related with oracles, blockchain bloat, cryptographic hash function or blockchain fork where males´ knowledge prevails over the females' one. On contrary, by the terms of mining, wallets, decentralized storage or smart contracts were females' knowledge higher than by males' counterparts. By the item of multi signatures we could observe similar knowledge by all genders.

In the following figure is displayed respondents´ knowledge of blockchain technology respondents correlated with the level of their study.

Based on the research data displayed in Fig 3., the respondents´ knowledge of blockchain is connected mostly with digital wallets, transaction fees, public address, private key, mining and decentralized storage. The least known areas are oracles, blockchain bloat, hashtable, blockchain fork or

hashpower.

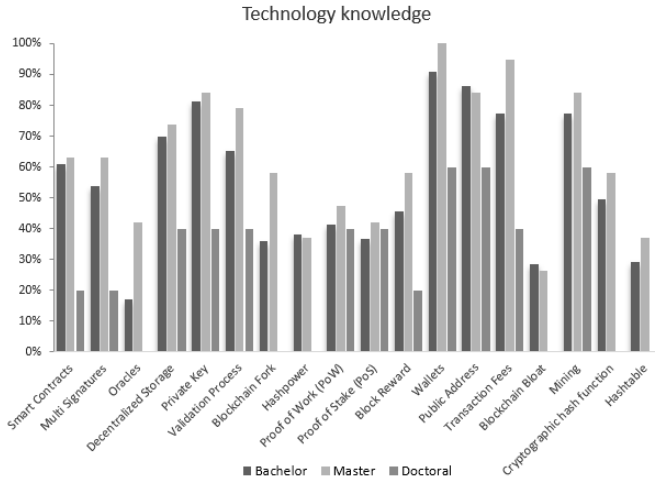

Fig. 3. Respondents´ knowledge of blockchain correlated with study level (Source: own research)

When we look into the data more in detail and correlate the knowledge of students determined by their study level, than we see that master students are the most informed ones in this area in comparison with bachelor and doctoral students. Having analyzed the students´ knowledge on particular study levels we can observe that bachelor students associate blockchain technology at most with digital wallets, public address, private key, transaction fees and mining. Looking at knowledge content by students on master level, it is obvious similar tendency like by bachelor students, however with slight differences in their order. The master students demonstrate their knowledge in the context of blockchain in following order – digital wallets, transaction fees, mining, public address and private key. As well students on the doctoral level marked similar items like students on lower levels known for them. However, for PhD candidates were some of the areas totally unknown. There was no knowledge detected for oracles, hash power, hashtable, blockchain fork and blockchain bloat.

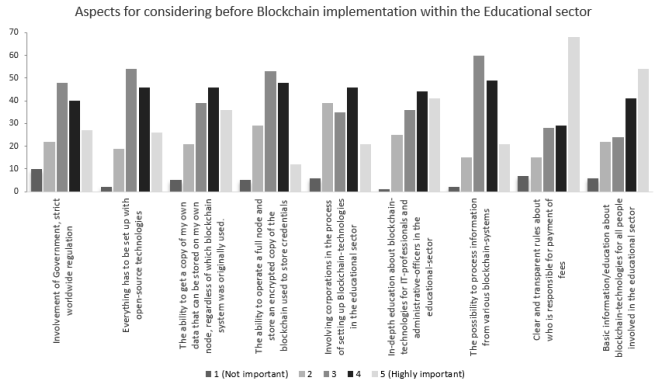

Fig. 4. Aspects to be considered before blockchain implementation (Source: own research)

We can see in the Fig. 4 which aspects perceive our respondents as very important to be considered before implementation of blockchain technology into the higher educational processes and agendas. As the most crucial seems to be "clear and transparent rules about who is responsible for payment of fees" (97 responses), followed by "basic information/education about blockchain-technologies for all people involved in the educational sector" (95 responses), "in-depth education about blockchain-technologies for IT-professionals and administrative-officers in the educational-sector" (85 responses), "the ability to get a copy of my own data that can be stored on my own node, regardless of which blockchain system was originally used" (82 responses). As the less important are seen the items "the ability to operate a full node and store an encrypted copy of the blockchain used to store credentials", "involving corporations in the process of setting up Blockchain-technologies in the educational sector" and "involvement of Government, strict worldwide regulation".
In the following part we can see how is blockchain technology viewed as suitable (or not suitable) for some selected areas within the educational sector.

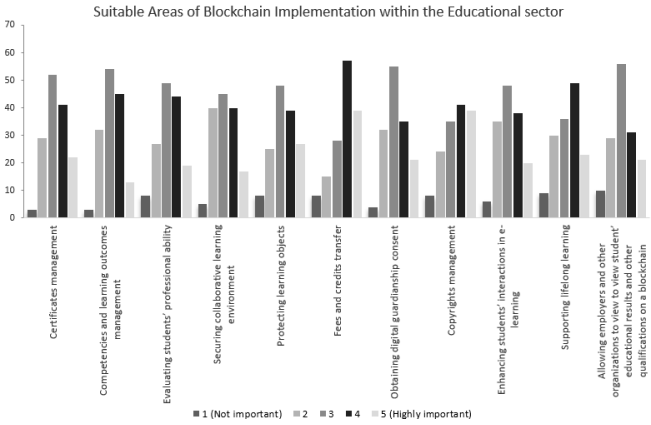

Fig. 5. Areas suitable for Blockchain Implementation within the Educational sector (Source: own research)

As shown in the Fig. 5 the most suitable for applying blockchain technology into the educational processes are perceived fields of "fees and credits transfer" (96 responses), "copyrights management" (80 responses), "supporting lifelong learning" (72 responses), "protecting learning objects" (66 responses) and "evaluating students' professional ability" + "certificates management" (with the same amount of 63 responses). As the least suitable are seen the areas of "securing collaborative learning environment" and "enhancing students' interactions in e-learning".

CONCLUSION

In our paper, we have introduced literature review and results of empirical research focused on finding answers on suitability of blockchain technology for its usage into the environment of higher educational institutions. Our main attention was paid towards revealing of awareness and knowledge of this modern technology in the context of educational processes. Based on literature review and gained empirical data it seems that the blockchain as a disruptive technology that provides unprecedented levels of security, can be perceived in general like a very adaptable in various areas. So, as well in the educational sector could be identified advantages related to usage of this technology like higher accuracy of transactions, no need for intermediaries, security, efficient transfers, decentralization, resistance and resilience

perceived like very beneficial.

Exploring the data towards the first research question "What is the knowledge of blockchain technology related towards educational sector?", we can conclude that our respondents are familiar with the concept of the blockchain and that their awareness and knowledge concerning to this technology has been systematically increased since 2014 when some of them have stated to hear about this technology for a first time. Looking at respondents' associations more in detail in the context of blockchain, they mentioned mostly digital wallet, public address, private key, transaction fees and mining. On the other hand, they were the least aware about oracle, blockchain bloat, hashtable and hashpower.

In the second part we have tried to find out which aspects influence implementation of blockchain technology into the educational sector. And, according to our respondents it seems that very important is clarity and transparency of rules and basic information/education about blockchain technology for all people involved in the educational sector.

In finding answer towards the question which areas are perceived as suitable for implementing of blockchain technology in education, our respondents concurred that fees and credits transfer, copyrights management and supporting lifelong learning are most suited for implementation of this modern technology. On contrary, they determined as least suitable securing collaborative learning environment and enhancing students' interactions in e-learning. This research has several limitations, which should be taken into account. Researchers collected data via online questionnaires with a certain number of respondents. For future studies, it is advisable to enlarge the sample size of the empirical research in order to produce a more comprehensive analysis. Moreover, the findings can be extended in the future by considering of involving more countries or sectors so as to realize a comparison in various environments which can represent a base for starting potential cooperation with the option of mutual compatibility in strategic solutions.

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