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Technology Readiness Index in The Application of Blockchain Technology In Indonesian Carbon Exchange

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ABSTRACT

The integration of Information and Communication Technology (ICT) with Blockchain technology has indeed brought about significant changes across various aspects of digital economic activities. This study provides a perspective on the influence of blockchain use on the performance of Indonesian Carbon Exchange players. The results of data analysis show that the variables Optimism (p-value 0.001<0.05) and Innovation (p-value 0.000<0.05) in the adoption of blockchain technology have a significant positive influence on the performance of Indonesian Carbon Exchange players. The results of testing the Insecurity variable on social media adoption showed significant negative results with a p-value of 0.002 (<0.05). And the results of testing the Discomfort variable with the adoption of blockchain technology have no influence on the performance of Indonesian Carbon Exchange players with a p-value of 0.074 (>0.05).

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INTRODUCTION

President Joko Widodo officially opened and launching Indonesian Carbon Exchange (IDXCarbon), at the Indonesian Stock Exchange (BEI) office, Tuesday (26/9/2023). In the context of trade there are sellers, buyers, and merchandise, each of which is played by countries that own forests (carbon absorbers, carbon absorbers), industrial countries (carbon producers, emitters), and carbon (CO2 compounds). This carbon buying and selling will be carried out through a scheme in accordance with international standards and as a consequence the selling country is obliged to protect and maintain the condition of its forests. Indonesia's reliance on nature-based solutions for carbon emission reductions underscores the importance of preserving and sustainably managing its natural resources. Leveraging its biodiversity and ecosystems effectively not only contributes to global climate efforts but also supports sustainable development and resilience against climate change impacts nationally and globally [1], [2].

Indonesia is the only country where around 60 percent of the reduction in carbon emissions comes from the natural sector," said President Jokowi. According to Boston Consulting Group (BCG) data, Indonesia's NBS potential is 1.4 Gte CO2 per year, so it is estimated that Indonesia's voluntary carbon credit market can reach IDR 60-85 trillion in 2030. The Voluntary Carbon Market (VCM) is part of carbon trading. The Technology Readiness Index (TRI) is a useful framework for understanding how prepared individuals or organizations are to adopt and implement new technologies. When applied to the context of blockchain technology in the Indonesian carbon exchange, the TRI can help assess various factors that might influence the successful integration and utilization of blockchain solutions [3].

On the other hand, Coordinating Minister for Maritime Affairs and Investment Luhut Binsar Pandjaitan estimates that domestic carbon trading activities through primary trading between business entities and secondary via the IDXC Exchange could reach US$1 billion to US$15 billion or the equivalent of Rp. 225.21 trillion (assuming an exchange rate of IDR 15,014 per US dollar) annually.

The rules regarding carbon trading are based on two Financial Services Authority (OJK) Regulations, namely POJK Number 14 of 2023 concerning Carbon Trading Through Carbon Exchange. Then, OJK Circular Letter (SEOJK) Number 12/SEOJK.04/2023 concerning Procedures for Organizing Carbon Trading Through Carbon Exchange. OJK has granted a business license to the Indonesia Stock Exchange (BEI) as a Carbon Exchange Organizer through OJK decision letter number KEP-77/D.04/2023 on Monday (18/9/2023). The projection that domestic carbon trading activities could reach US$1 billion to US$15 billion annually, equivalent to approximately Rp. 225.21 trillion assuming an exchange rate of IDR 15,014 per US dollar, underscores the potential economic impact of carbon trading in Indonesia [4], [5].

IDX President Director Iman Rachman said, apart from providing price transparency, IDXCarbon trading also provides an easy and simple transaction mechanism. Currently there are four IDXCarbon trading mechanisms, namely Auction, Regular Trading, Negotiated Trading, and Marketplace. “IDXCarbon is an important milestone for Indonesia's decarbonization commitment towards Net Zero Emissions by 2060 or sooner. "IDXCarbon strives to provide transparency, reliability and security in providing the best solutions for carbon trading in Indonesia so as to create orderly, fair and efficient trade," said Iman, Tuesday (26/9/2023). He continued, by providing a

platform that prioritizes experience, it is hoped that all business actors will easily benefit from carbon trading. For information, IDXCarbon is connected to the National Registration System for Climate Change Control (SRN-PPI) belonging to the Ministry of Environment and Forestry (KLHK), making it easier to administer the transfer of carbon units and avoiding double counting [6].

Carbon Unit (Carbon Credit) is proof of carbon ownership in the form of a certificate or technical approval expressed in 1 (one) ton of carbon dioxide recorded in the SRN PPL. This refers to Presidential Regulation Number 98 of 2021 concerning Implementation of Economic Carbon Value to Achieve Nationally Determined Contribution Targets and Control of Greenhouse Gas Emissions in National Development. Carbon credits then become units traded in carbon trading for carbon offsets. Carbon offset itself is an effort to balance carbon emissions from certain activities through purchasing carbon credits in the voluntary market (Voluntary Carbon Market) [2].

By managing emissions through a cap-and-trade system, countries like Indonesia can effectively control greenhouse gas emissions and contribute to global efforts to combat climate change by implementing such systems, countries can effectively control and reduce their greenhouse gas emissions, contributing to global climate goals while encouraging economic and technological advancements in sustainability [7]. The way to calculate carbon credits currently agreed upon by the world is to use the Reduction of Emissions due to Deforestation and Forest Degradation Plus (REDD+) scheme. REDD+ is a concept to reduce greenhouse gas emissions due to deforestation and forest degradation plus conservation, sustainable management of forests and increasing forest carbon stocks in developing countries. It is important to calculate carbon credits before taking action related to saving the environment. The stages in REDD+ agreed upon throughout the world are measurement, verification, then action (MRV). MRV is a system for documenting, reporting and proving carbon changes consistently, completely, transparently and accurately so that it can be accepted internationally. MRV can assist the government in establishing initial (baseline) carbon emissions as a basis for calculations in the carbon trading mechanism (carbon market). Referring to IPCC-GL 2006, the calculation of carbon stock data and changes needs to take into account five carbon sources (carbon pools), namely soil, litter, dead trees, biomass below and above ground [7], [8].

Blockchain technology is a technology used as a digital storage system or data bank connected to cryptography. This technology utilizes computer resources to create connected blocks (chain). The blocks that are connected to each other are later used to execute a transaction. This technology is quite interesting because of its non-centralized nature. Blockchain is able to run itself using computer algorithms without any particular system managing it [9], [10].

The Voluntary Carbon Market (VMC) has a trust problem the quality and efficacy of the existing supply of carbon credits generates widespread skepticism. Since its inception, VCM – a decentralized market where private actors buy and sell carbon credits – has existed without uniform quality standards or generally agreed accounting principles. Without these steps, certification options will crowd the market and buyers of carbon credits will often be unable to distinguish the signal from the noise. A lack of transparency

also impacts the credibility of climate benefit claims. For these markets to reach their full potential, the carbon credit data within them must be reliable and accurately monitored. To overcome these challenges, blockchain technology offers a promising solution to increase transparency and efficiency in carbon markets [8], [11].

The Technology Readiness Index (TRI) measures a person's tendency to accept and use technology to accomplish goals in home life or at work. The main construct in the TRI model is an individual's readiness to adopt IT based on general personality characteristics and contributory or inhibitory factors to new technology. The following are the constructs in the TRI model [12]. 1) Optimism, namely a positive view of technology. Positive beliefs about technology can increase control, flexibility, and efficiency in life because of technology. 2) Innovation, namely the tendency to be the first user of a new technology. 3) Discomfort, namely feelings of being overwhelmed and inability to control new technology. 4) Insecurity, namely distrust of new technology for security and privacy reasons [13]. Performance is influenced by the utilization of existing resources in operational activities. Non-financial performance indicators (NFPI) are a measure of how well an organization achieves its strategic goals, such as customer satisfaction, employee engagement, innovation, quality, or social responsibility [14], [15].

RESEARCH METHOD

In this research, researchers used quantitative research. Quantitative research is research specifically for processing data in the form of numbers. Quantitative research can make it easier for researchers to process numbers which will later be carried out with regression analysis using the SmartPLS 3.2.7 application. The scope of this research is carbon trading actors at the start of IDXCarbon trading. The provider of Carbon Units in this initial trade is Pertamina New and Renewable Energy (PNRE) which provides Carbon Units from the Lahendong Unit 5 and Unit 6 Project of PT Pertamina Geothermal Energy Tbk. (PGEO). Meanwhile, companies acting as buyers of Carbon Units include PT Bank Central Asia Tbk. (BBCA), PT Bank CIMB Niaga Tbk. (BNGA), PT Bank DBS Indonesia, and PT Bank Mandiri (Persero) Tbk. (BMRI). Then PT BNI Sekuritas, PT BRI Danareksa Sekuritas, PT CarbonX Bumi Harmoni, PT MMS Group Indonesia, PT Multi Optimal Research and Education, and the subsidiary PT United Tractors Tbk. (UNTR), namely PT Pamapersada Nusantara. Apart from that, several subsidiaries of PT Pertamina (Persero) are also buyers of carbon units, such as PT Pelita Air Service, PT Pertamina Hulu Energi, and PT Pertamina Patra Niaga.

This research uses primary data. The data collection technique used was Purposive Sampling with Judgment Sampling specifications through distributing questionnaires using a Likert scale. Judgment Sampling is a planned sample selection technique, people who can be used as samples for research if there is someone who is willing to fill out a questionnaire and meets the criteria required by the researcher.

The population to be studied is carbon trading actors at the start of IDXCarbon trading. Meanwhile, determining the number of samples in this research is based on Roscoe in Husen (2012) [16], which is 10 times greater than the number of variables in the research. This research has 5 variables studied so that the researcher determined the use of a sample of 56 samples. This number is considered to represent 10 times greater than the number of variables in the

research according to the determination of the sample size.

The analysis technique in this research uses multivariate analysis that analyzing data with multiple variables to reveal relationships, patterns, or to make predictions [17]. The model used is Partial Least Square Regression (PLS-R). In processing it uses the SmartPLS 3.2.7 application. The collected Likert data is first transformed into interval data. To convert data to intervals use the successive interval method. After that, an inner model test will be carried out with criteria such as T-statistics, Probability value and R2. Continue with the outer model test to see the validity and reliability tests and finally hypothesis testing in table 1.

Table 1. Operational Definition of Variables

Variable	Definition Operational
OPT (Optimism)	A positive view of the technology and a belief that blockchain offers increased control, flexibility and efficiency in life.
INV (Inovation)	Describes the efforts of Carbon Exchange players in creating new things through blockchain technology that occur in the process of adopting information technology.
DSC (Insecurity)	Describes distrust of processes or systems in technology information and communication that occurs in the blockchain adoption process.
DCF (Inconvenience)	Describes the lack of control over information technology that occurs in the blockchain adoption process.
KIN (Performance)	Focused on non-financial performance. Bursa Carbon's performance is defined primarily by the existence of more efficient internal business processes.

Source: Octavia, 2015 [6]

Based on the hypotheses provided, it appears exploring the potential impacts of various factors related to blockchain technology implementation on the performance of a Carbon Exchange, these hypotheses provide a structured framework to investigate how attitudes (optimism), advancements (innovation), concerns (insecurity), and challenges (discomfort) related to blockchain technology implementation might influence the performance of a Carbon Exchange.Hi from this research is:

H1: It is suspected that optimism (X1) in implementing blockchain technology has a significant positive effect on the performance of the Carbon Exchange.

H2: It is suspected that innovation (X2) in implementing blockchain technology has a significant positive effect on the performance of the Carbon Exchange.

H3: It is suspected that insecurity (X3) in implementing blockchain technology has a significant positive effect on the performance of the Carbon Exchange.

H4: It is suspected that discomfort (X4) in implementing blockchain technology has a significant positive effect on the performance of the Carbon Exchange.

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RESULT AND DISCUSSION

Data analysis in a study aims to find out whether the data that has been obtained in the research process meets certain criteria in order to pass a test. The analysis was carried out using the SmartPLS 3.2.7 application which aims to find out whether each indicator and question item in the questionnaire can be declared valid or not. After carrying out regression using SmartPLS 3.2.7, the following results were obtained in figure 2.

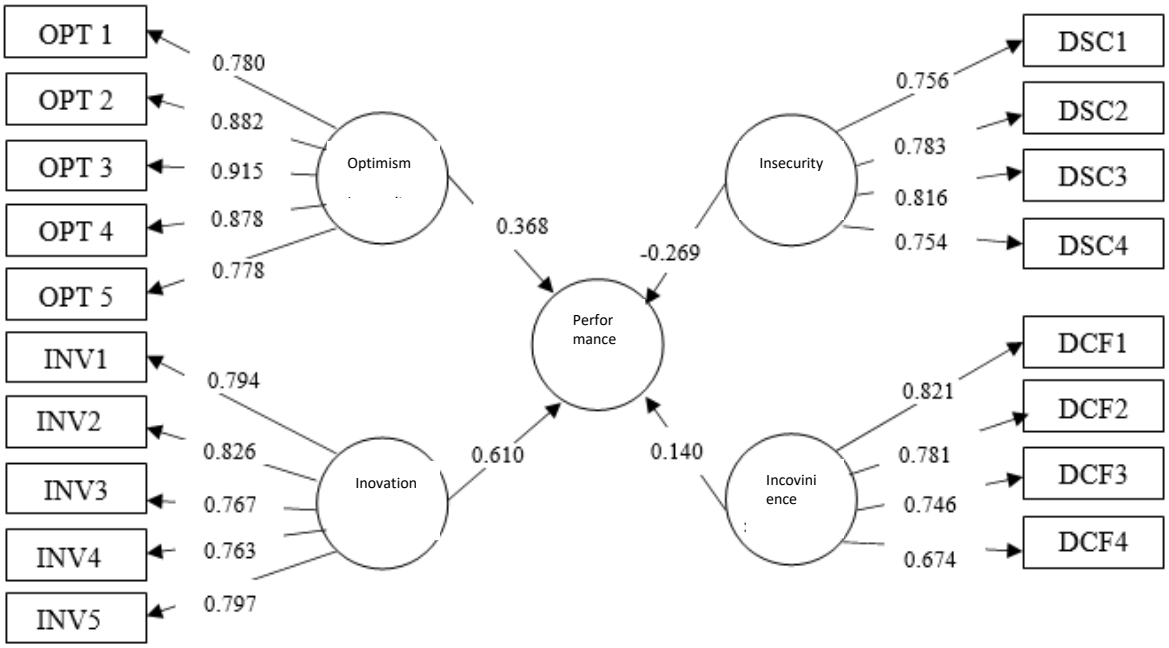

Figure 2. Partial Least Square Regression Model
Source: data processed, 2023

Looking at the regression results above, the model can be obtained:

KIN = 0.368OPT + 0.610INV - 0.269DSC + 0.140DCF (2)

Based on this data, it can be seen that the value of the Optimism variable (OPT) on the Performance of the Indonesian Carbon Exchange is 0.368. The Innovation Variable (INV) on the Performance of the Indonesian Carbon Exchange is 0.610. The Insecurity Variable (DSC) on the Performance of the Indonesian Carbon Exchange is -0.269. This coefficient indicates the strength and direction of the relationship between insecurity (DSC) and the performance of the Indonesian Carbon Exchange. A coefficient of -0.269 suggests a negative relationship.

Interpretation: For every unit increase in the insecurity variable (DSC), the performance of the Indonesian Carbon Exchange is expected to decrease by 0.269 units, assuming all other factors remain constant. The Discomfort Variable (DCF) on the Performance of the Indonesian Carbon Exchange is 0.140.

Table 2. Outer Model Test Results

Variabel	Average Variance Extracted	Cronbach's Alpha
Carbon Exchange Performance	0.648	0.819
Optimism	0.720	0.902
Inovation	0.624	0.850
Insecurity	0.605	0.784
Inconvenience	0.574	0.758

Source: data processed, 2023

Based on the results of the outer model test in table 2, it can be explained that all the variables used in this research passed the validity test, because all variables have an AVE value that exceeds 0.5 and it can be said that the instruments used in this research is valid in measuring something that is being measured. Apart from that, all variables were declared to have passed the reliability test because the Cronbach's Alpha value was more than 0.7 so that the indicators in this study could measure the consistency of respondents in answering each question item.

Table 3. Inner Model Test Results

Variable			*T-Statistics*	*Probability Value*
Optimism	→	**Performance IDXC**	3.457	0.001
Inovation	→	**Performance IDXC**	5.536	0.000
Insecurity	→	**Performance IDXC**	3.099	0.002
Inconvenience	→	**Performance IDXC**	1.788	0.074

Source: data processed, 2023

Based on the results of the outer model test in table 3, it can be explained that the independent variables (Optimism, Innovation, Insecurity) have a significant effect on the Indonesian Carbon Exchange Performance variable because the overall T-statistics value is more than 1.96 and the P-Values value is less than 0.05. Meanwhile, the Discomfort variable does not have a significant effect on the Indonesian Carbon Exchange Performance variable because the overall T-statistics value is less than 1.96 and the P-Values value is more than 0.05.

Table 4. R-Square Test

Dependent Variable	R-Square
Performance IDXC	0.874

Source: data processed, 2023

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Based on table 4, it can be seen that the R-Square of the Indonesian Carbon Exchange Performance variable as the dependent variable can be explained by the Optimism, Innovation, Discomfort and Discomfort variables of 0.874 or 87.4 percent, while 12.6 percent is explained by other variables outside those studied that shown in table 5.

Table 5. Hypothesis Testing

Variable	*P-value*	Hipotesis test	Remark
Optimism	0.001	H1 Accepted	Positive influence on the performance of the Indonesian Carbon Exchange
Inovation	0.000	H2 Accepted	Positive influence on the performance of the Indonesian Carbon Exchange
Insecurity	0.002	H3 Rejected	Negative influence on the performance of the Indonesian Carbon Exchange
Inconvenience	0.074	H4 Rejected	Negative influence on the performance of the Indonesian Carbon Exchange

Source: data processed by the author, 2023

RESULT AND DISCUSSION

Data analysis that has been carried out previously shows that the optimism variable has a positive and significant effect on the performance of the Indonesian Carbon Exchange. This means that the higher the optimism that the Indonesian Carbon Exchange players have regarding blockchain technology which is used as a form of information technology adoption, the performance of the Indonesian Carbon Exchange players will also increase.

The question item "Carbon units and services that use blockchain are much more profitable" received an affirmative answer of 60.7 percent. The optimism that Indonesian Carbon Exchange players have in using blockchain technology for their business activities is not only related to the profits obtained, but includes more flexible time, maintaining good relationships with consumers, more efficient work patterns and making business decisions easier. Indonesian Carbon Exchange players use bockchain technology because they can expand their network and be efficient and thus support performance. This is illustrated when the majority of Indonesian Carbon Exchange players agree that their market share and network reach will become wider with a percentage of 60.7 percent and 16 percent who answered strongly agree. The wider market that can be reached will certainly influence the magnitude of the benefits that can be received by the Indonesian Carbon Exchange.

The innovation variable has a positive and significant effect on the performance of the Indonesian Carbon Exchange. This means that the higher the innovation that the Indonesian Carbon Exchange players have in using blockchain technology, the performance of the Indonesian Carbon Exchange players will also increase. Supported by research by Jones et al (2011) [18], that innovation creates value for new and established Indonesian Carbon Exchanges so that the innovation process that brings more benefits to the performance of the Indonesian Carbon Exchange is strategic innovation. Strategic

innovation includes new ideas, novelty, experiments and creative processes that can produce new products, services, technological processes [19].

Apart from that, the form of innovation carried out on blockchain can also be seen in the appearance of accounts and product designs which aim to attract consumers. The impact of innovation on blockchain technology carried out by the Indonesian Carbon Exchange can be illustrated when asked the question "Transaction activities have been more efficient in the last 2 months" there was an affirmative answer of 58.9 percent. This means that innovation carried out on blockchain is very necessary to help the efficiency of performance of the majority of Indonesian Carbon Exchange players [20].

The insecurity variable has a negative and significant effect on the performance of the Indonesian Carbon Exchange. This means that the lower the level of insecurity that the Indonesian Carbon Exchange players have, the performance of the Indonesian Carbon Exchange players will increase. Based on the Technology Readiness Index theory, insecurity means that users do not believe in the capabilities of a technology. The condition of Indonesian Carbon Exchange players who accept the risk of insecurity from the use of technology shows that users have adopted the good and bad sides resulting from the application of blockchain to information and communication technology [18].

There are those who think that their consumers really understand the investment products they offer because each manufacturing process by different people will also have differences in the results. These results are supported by research conducted by Holden et al (2010) [3], it is known that a feeling of job insecurity is negatively related to job performance.

The discomfort variable has no effect on the performance of the Indonesian Carbon Exchange. Looking at conditions in the field, Indonesian Carbon Exchange players are not affected by the discomfort experienced in using blockchain applications on investment performance. This is because when there are uncomfortable conditions, which means there is a feeling of lack of mastery of technology and lack of confidence in using technology, Indonesian Carbon Exchange actors can employ qualified admins who are dedicated to managing blockchain applications.

Obstacles in mastering technology are not a problem for the Indonesian Carbon Exchange players, because there are management and design services so that investment performance is not affected. This condition was illustrated when asked the question "I feel exploited by other parties when my ability to master blockchain applications is limited" and 41 percent disagreed. This means that even though Indonesian Carbon Exchange players have limited capabilities in adopting blockchain in investment applications, they still feel comfortable in using it even though they have to involve other parties so that it does not impact their performance.The statement suggests that despite limitations in adopting blockchain technology for investment applications within the Indonesian Carbon Exchange, participants still find it feasible and are willing to engage with it.

The statement highlights that while there are challenges, these do not significantly impair the performance of the Indonesian

Carbon Exchange. This suggests that stakeholders are managing to navigate the complexities associated with blockchain adoption effectively enough to maintain operational performance and possibly derive benefits from using blockchain despite the initial hurdles [1].

The research finding that the discomfort of Indonesian Carbon Exchange players in adopting blockchain technology has no effect on their respective business performance is intriguing and has several implications. Strategic Recommendations Develop a Roadmap: Create a clear roadmap for blockchain adoption that includes phased implementation, stakeholder engagement, and external support. Establish partnerships with technology providers, consultants, and other external experts to address technical challenges and enhance integration. Regularly assess performance metrics to ensure that business objectives are being met, regardless of the internal discomfort with new technologies. Encourage knowledge sharing and collaboration within the industry to build a more robust understanding of blockchain technology and its benefits. By acknowledging and addressing the discomfort with blockchain adoption while leveraging external expertise, Indonesian Carbon Exchange players can navigate technological changes effectively and maintain or even enhance their business performance in the digital economy [13].

CONCLUSION

Based on the research results and discussions described in the previous chapter, the following conclusions can be drawn Indonesian Carbon Exchange players have high optimism in the use of blockchain which is used as a form of adoption of information and communication technology followed by the performance of Indonesian Carbon Exchange players also increasing. The adoption of blockchain technology that will be carried out can provide more benefits compared to conventional methods because it will increase the effectiveness of working time and minimize costs to gain a wider market. Indonesian Carbon Exchange players who have high innovation in using blockchain in information technology will be able to improve the performance of Indonesian Carbon Exchange players. Innovations made by Indonesian Carbon Exchange players on blockchain include a special program for investment management integration so that sales targets can be achieved. Insecurity in blockchain adoption has a negative effect on the performance of Indonesian Carbon Exchange players. The lower the level of insecurity owned by the Indonesian Carbon Exchange players, the performance of the Indonesian Carbon Exchange will increase. The Indonesian Carbon Exchange will have a level of security in using blockchain as an adoption process so that performance will increase. The discomfort of Indonesian Carbon Exchange players in adopting blockchain has no effect on their respective business performance. To achieve performance efficiency in the demands of digital economic development, Indonesian Carbon Exchange players can utilize the abilities of other parties outside the business to maintain performance. Based on findings in the field and research results, there are suggestions from the author as follows. Judging from optimism, so that more good benefits can be obtained in the development of business models and the digital economic environment, new standards are needed for Indonesian Carbon Exchange players as a reference, so that every form of IT application

development is in accordance with needs. Judging from innovation and seeing the age distribution of business actors, many of whom are between 31-45 years old, it would be even better if the training and development provided by the agency also captures and facilitates the participation of the younger generation so that a wider range of ideas can be developed. Judging from insecurity, it is hoped that the licensing process related to the required documents and permits will be more consistent in terms of time so that Indonesian Carbon Exchange players are not hampered when handling large-scale transactions. This will further increase the sense of security of Indonesian Carbon Exchange players and consumers in running their business. As well as the need for clearer regulations regarding foreign transaction and derivative activities to be disseminated to the public. Judging from the inconvenience, Indonesian Carbon Exchange actors should also be intensified in strategic innovation training which includes the use of renewable technology, services and appropriate use of existing resources. And it is recommended that training given to Indonesian Carbon Exchange players related to information and communication technology also be accompanied by training related to account maintenance.

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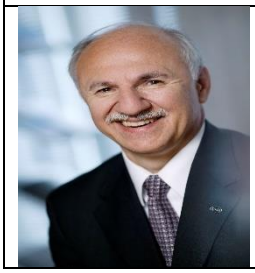

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