Jurnal BPPK Volume 17/2024 Halaman 51-65

BADAN PENDIDIKAN DAN PELATIHAN KEUANGAN
KEMENTERIAN KEUANGAN
REPUBLIK INDONESIA

JURNAL BPPK

STRATEGY FOR PREPARING CBDC IMPLEMENTATION IN NORTH SUMATRA

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ARTICLE INFORMATION

ARTICLE HISTORY
Received
13 Maret 2024

Accepted to be published
12 Desember 2024

KEYWORDS:
Classification and Regression Trees (CART),
Resampling,
CBDC,
e-banking.

ABSTRACT

Penelitian ini bertujuan untuk mengetahui karakteristik dan mengidentifikasi faktor-faktor yang mempengaruhi masyarakat Sumatra Utara yang adaptif terhadap penerapan CBDC yang didekati oleh masyarakat yang mengakses *e-banking*. Kami menemukan bahwa karakteristik masyarakat yang adaptif terhadap penerapan CBDC adalah lulusan perguruan tinggi; tamat SMA/sederajat dan berdomisili di perkotaan; serta tamat SMA/sederajat, tinggal di pedesaan, dan bekerja pada industri pengolahan, keuangan, kegiatan asuransi, administrasi pemerintahan, pertahanan, jaminan sosial wajib, pendidikan, kegiatan kesehatan manusia, dan kegiatan sosial. Temuan ini menunjukkan bahwa penerapan CBDC perlu mempertimbangkan karakteristik individu.

This study aims to determine the characteristics and identify the factors that influence the people of North Sumatra who are adaptive to the implementation of CBDC that is approached by people who access e-banking. We find that characteristics of people who are adaptive to the implementation of CBDC are college graduate; finished high school/equivalent and living in urban areas; and finished high school/equivalent, living in rural areas, and working in processing industries, finance, insurance activities, government administration, defense, compulsory social security, education, human health activities, and social activities. These findings suggest that the CBDC implementation should take into account individual characteristics.

1. INTRODUCTION

1.1. Background of Study

The financial sector is an important sector in the Indonesian economy that has been affected by the Covid-19 pandemic. Public concerns about being exposed to the Covid-19 virus have changed people's behavior, including in financial transactions. The shopping system that was originally mostly done offline has shifted online. This has implications for the payment system by which people switch from physical money to electronic money. Figure 1 shows the high increase in the volume of electronic money transactions in 2020, the first year when Indonesia was exposed to the Covid-19 pandemic.

The condition under the Covid-19 pandemic, followed by technological advances has provided a new revolution in the banking system. The financial sector continues to innovate, one of which is the emergence of financial technology (Fintech). Fintech or digital finance is a financial service that utilizes technology in the form of digital infrastructure by reducing the use of cash and traditional banking services (Horvathova, 2018). Digital finance combines financial services with adaptive and innovative technology (Rodin et al., 2019). One of the digital financial services is cryptocurrency. Cryptocurrencies are digital currencies that are used to make financial and banking transactions virtually. Cryptocurrency is an encrypted algorithm because it is designed to be anti-hacking and transactions are carried out using the internet (Fatarib & Sali, 2021).

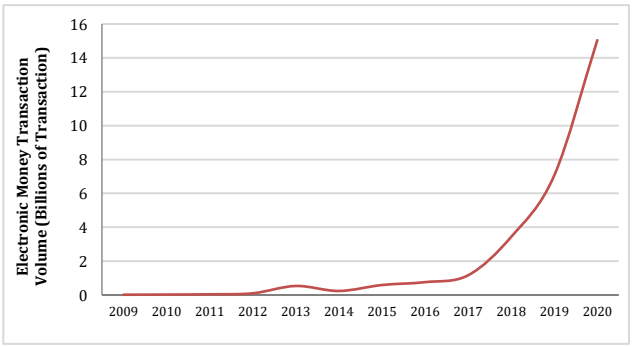

Figure 1.
Electronic Money Transaction Volume in Indonesia (2009 to 2020)

Source: Bank Indonesia

Financial service innovations, including cryptocurrencies, are still run by private parties, which should be the central bank's domain as a financial institution that regulates monetary and financial policies as well as various other innovations (Krisna Wijaya, 2019). This has the potential to create risks such as financial risks for users due to fluctuating values and unreasonable price increases (Fairi et al., 2021), including potential legal violations due to pseudonymous mechanisms (real names and personal details are unknown) that apply to transactions using cryptocurrency (Latimer & Duffy, 2019). In addition, developments and innovations in the financial sector are believed to change the foundation and basic structure of the central bank and users of financial services (Carney, 2016; Triantono & Aryusmar, 2019). In response to these various issues, Bank Indonesia is currently reviewing and developing the concept of a Central Bank Digital Currency (CBDC) (Zams et al., 2020).

CBDC has several advantages, namely globally accepted, reliable, and inclusive, can be used as more stable cash, can be used for the implementation of certain fiscal and monetary policies, and has greater oversight, easier to track as efforts to prevent crime in the financial system (Hariyanto, 2021). In addition to several advantages, CBDC also provides several risks such as technological readiness, economic conditions, applicable legal provisions, and community readiness and conditions (Carney, 2016).

Community readiness certainly plays an important role in the implementation of CBDC in Indonesia. At the same time, people who invest using digital money are increasing (Khasanah & Farida, 2020). One of the provinces that continues to experience an increase in digital financial transactions is North Sumatra. Figure 2 shows that the number of electronic money cards/instruments in North Sumatra in 2021 has increased every month when compared to 2020.

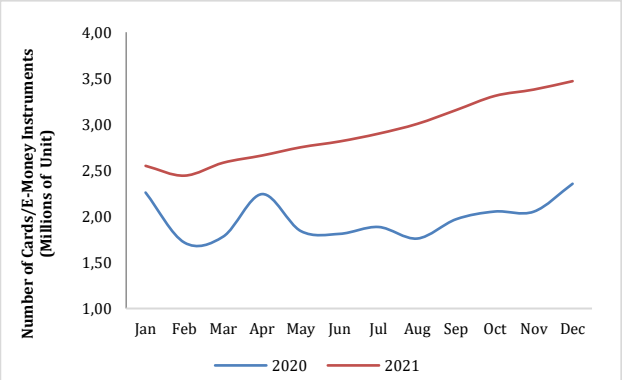

Figure 2.
Number of Cards/E-Money Instruments in North Sumatra
(January 2020 to December 2021)

Source: Bank Indonesia

The central bank certainly needs to know the literacy conditions of digital money users in preparation of CBDC implementation. To begin with this, the central bank needs to understand the characteristics of banking users who have used internet facilities to access banking facilities. The implementation of CBDC without paying attention to and understanding the characteristics of customers is at risk of causing the implementation of the program not to run properly. This study aims to capture the characteristics of people who access the internet for banking facilities (e-banking). The detection of these community characteristics can be used as an initial indicator that measures how deep the penetration of digital money use is in society.

Taking into account the various problems previously described, by conducting random oversampling and random undersampling Classification and Regression Trees (CART) approach, this study will explain how the characteristics of people who access the internet for e-banking and the factors that influence them in North Sumatra. This study is limited by examining only residents aged 17 years and over.

2. LITERATURE REVIEW

2.1. Teoritical Framework

The CBDC option emerged as a response to the high demand for digital money, mainly triggered by digitalization in various sectors including the financial sector during the turmoil of the Covid-19 pandemic. However, a standard definition of CBDC is not yet available (CPMI, 2018; Didenko et al., 2021).

The CBDC concept was first introduced by the Bank for International Settlements (BIS) in 2018 in a report submitted by the Committee on Payments and Market Infrastructures (CPMI). The report states that at least 40 central banks in the world are studying CBDC. The adoption of CBDC as a digital currency is inevitable from research conducted by Tobin (1985) which stated the importance of providing digital access by central banks.

CBDC is not just a currency but a combination of digital technology in the financial sector. CBDC is a digital framework as well as a complex tool. The application of this instrument is a breakthrough in the economic sector (Didenko et al., 2021) and raises great hopes, especially in providing financial transactions that are more comfortable, tough, friendly, and can be widely accessed and operated. (CBDC-WG, 2020). However, this instrument is considered complex because of its character which combines digital and information technology applied in the financial sector. More than that, implementing CBDC has different challenges because of its implementation in the form of massive distribution and use.

CBDCs can be equated to digital banknotes, but in practice these instruments may have other features depending on the final design (BoE, 2020). This instrument offers several advantages, including encouraging innovation, especially in the provision of payment systems, which ultimately helps

encourage economic growth (Koumbarakis et al., 2019); cheaper compared to paper money because it avoids the costs of production, storage, transportation, and disposal (Gnan et al., 2018); technological efficiency because it does not have to rely on intermediaries and can increase the speed of transaction completion in real time (Wadsworth, 2018); as well as assisting the transmission of monetary policy by the central bank through controlling the money supply (Wadsworth, 2018).

CBDC is like paper money where claims on this instrument can be made directly (Auer et al., 2021) even though it is in digital form (Purnawan & Riyanti, 2019). One factor that needs to be considered before implementing CBDC is the readiness of infrastructure, especially in economies with a wide geographical scope. Internet connections that reach all economic geographic areas must be available so that every individual in society can use this instrument (Wadsworth, 2018).

Based on the usage scenario, CBDC can be categorized as wholesale CBDC and retail CBDC (BoE, 2020). Wholesale CBDC is a new infrastructure for settlement between banks, such as payments between banks and other entities that have a direct relationship with the central bank. Wholesale CBDC can improve interbank payment settlement, reducing the risks and costs of cross-border payment transactions. Meanwhile, retail CBDC is a digital version of cash and is mainly used for payments between individuals and businesses. Retail CBDCs can improve access and usability for users, reduce costs for e-commerce and cross-border payments, and help improve monetary policy (Zhang et al., 2022).

The application of CBDC in retail form, where this instrument is used like banknotes to reach all users, not only those in the banking industry, of course also needs to pay attention to other social aspects, including from a legal perspective as well as from the cultural and individual character of the people who will use it.

2.2. Prior Research

Most articles discussing CBDC examined the readiness of information technology infrastructure in implementing this financial instrument. Dionysopoulos *et al.* (2024) provided an analysis of CBDC, exploring their motivations, design, implications for monetary policy and financial stability, and identifying areas requiring further research. Fahad and Bulut (2024) systematically reviewed the global literature on CBDC, analyzing research methodologies, data usage, and key findings to provide a comprehensive evaluation of academic efforts, identify trends, and offer a valuable resource for researchers, policymakers, and stakeholders navigating the complexities of digital financial innovation.

Ozili (2023) analyzed how CBDC influences bank earnings management through accruals like loan loss provisions (LLPs), highlighting its impact on reported earnings amid CBDC-induced disintermediation and contributing to the growing literature on CBDC's role in corporate and societal contexts. Furthermore, Ozili (2024) investigated the determinants of global interest in CBDC, analyzing Google Trends data to reveal significant relationships with interest in sustainable development, cryptocurrency, and specific CBDC.

Chen and Siklos (2022) examined the challenges of deploying CBDC, analyzes the potential impacts of narrow and broader CBDC forms on inflation and financial stability using historical and cross-country data, and provides policy implications to address associated risks. Besides that, Wang (2022) using over 660 million news stories from LexisNexis News & Business (2015-2021) introduced the CBDC Uncertainty Index (CBDCUI) and CBDC Attention Index (CBDCAI), showing their significant relationships with market volatilities and providing valuable insights for investors, policymakers, and regulators on the evolving role of CBDCs in the digital currency era.

Other article was a proposed multi-blockchain data center model for CBDCs to help central banks manage currency issuance and protect user privacy (Sun et al., 2017). While Wagner et al. (2021) proposed a blueprint for a digital euro. Lee et al. (2021) proposed a blockchain-based settlement system using the cross-chain atomic swaps method which can be applied in managing the risk of problem settlement in a CBDC.

Apart from that, there were quite a few studies explaining the relationship between CBDC and the banking industry. Cukierman (2020) provided two proposals for CBDC implementation, namely moderate where only the banking sector can have access to deposits at the central bank, and radical where the entire private sector can hold digital currency deposits at the central bank. Meanwhile, several studies discuss the new role of central banks in the digital currency era. Some believe that CBDC could disrupt commercial banking because central banks are more stable and can play an important role in reducing risks in economic transactions (Sinelnikova-Muryleva, 2020; Yamaoka, 2019; Zams et al., 2020). This could even lead to a commercial banking panic (Williamson, 2022) or a deposit-monopolizing central bank function (Fernández-Villaverde et al., 2021).

Several studies have also examined the risks of implementing CBDC from a legal perspective. This is motivated by the possibility of money laundering transactions using digital money (Wang et al., 2022), including cyber security threats (Emanuella, 2021). In the case of Indonesia, the implementation of CBDC as a currency must be based on legal documents that explain its function as a legal means of payment for every transaction carried out by the public (Nurullia, 2021).

On the other hand, research examining the characteristics of CBDC users was still rare. CBDC is designed for people and institutions that use money as a means of transactions. Incorporating different types of users who vary in age, geographic location, payment habits, and financial literacy can help hone the basic features of a viable CBDC setup (Cheng et al., 2021). Meanwhile, Bijlsma et al (Bijlsma et al., 2021) used primary data in the Netherlands by including age and savings ownership variables to find the possibility of a customer opening a CBDC account.

In the case of Indonesia, studies that discussed the relationship between demographic elements of the population and breakthroughs in the world of financial information technology were still limited. This included making e-banking transactions a discussion issue in these studies (Hermana, 2010; Pukuh et al., 2021; Puruhita, 2019; Susanto et al., 2013). Several other studies even concluded that there was a significant influence between gender, age and education level on the use of e-banking services in Indonesia (Abrar, 2021; Lisara, 2017; Ngasuko, 2020), although no research has been found that examines the Sumatra region.

2.3. Conceptual Framework

This research examines the individual characteristics of the people of North Sumatra and their readiness to face the implementation of CBDC in this province. The use of e-banking by the people of North Sumatra is used as an approach to determine the community's literacy regarding developments in the world of banking, especially in applying information technology. The people of North Sumatra who have used e-banking are assumed to have better literacy regarding the digitalization of the banking world and are relatively more ready to adopt CBDC compared to people who have not used it. Identifying the characteristics of individuals who have adopted e-banking can be used as an initial step that can be taken by Bank Indonesia in determining outreach, promotion and education strategies for people who have not yet adapted to e-banking.

Five of the six individual characteristic variables used in this study were based on other similar studies (Abrar, 2021; Ngasuko, 2020). One of the ways in which the gap analysis in this study is shown by including the variable type of business field as one of the individual characteristics that will be observed.

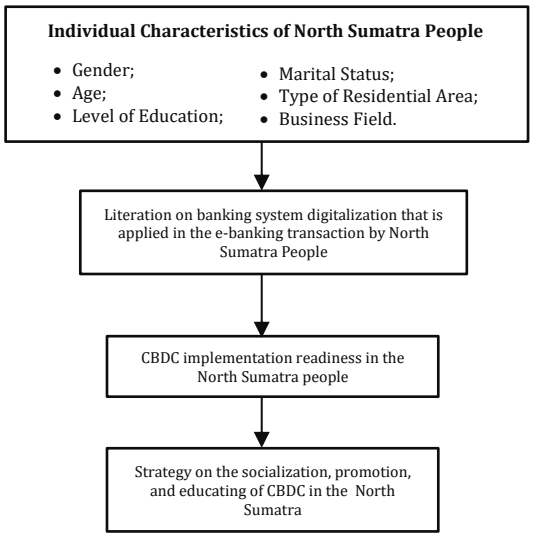

Figure 3.
Conceptual Framework

3. RESEARCH METHODOLOGY

3.1. Data Set

The data used in this study is data from the March 2020 National Socio-Economic Survey (SUSENAS) for North Sumatra, which comes from BPS-Statistics Indonesia. The master sampling frame used in the implementation of the 2020 SUSENAS is around 40 percent of the census block of the population, which is drawn using probability proportional to size (PPS) with the size of the number of households in SP2010 (BPS, 2019a).

The population target in this study is people aged 17 years and over in North Sumatra. The total data used is 52.955 residents. The response variable used in this study is the status of accessing the internet for e-banking (code 1: accessing e-banking and code 2: not accessing e-banking). Accessing the internet for e-banking means making electronic transactions with banks for payments, transfers, or searching for account information (BPS, 2019b). The explanatory variables and the concepts used in this study are shown in Table 1.

Table 1
Explanatory Variable

Number	Variable Name	Category
1	Level of education	1. Did not finish elementary school 2. Graduated from elementary school/equivalent 3. Graduated from junior high school/equivalent 4. Graduated from high school/equivalent 5. Graduated from college
2	Gender	1. Male 2. Female
3	Marital status	1. Not Married 2. Married 3. Divorced

4	Type of residential area	1. Urban 2. Rural
5	Business field	1. Agriculture 2. Manufacturing 3. Wholesale and retail trade 4. Financial activities 5. Government administration 6. Education 7. Human health and social activities 8. Others (mining; procurement of electricity, gas, and water; construction; transportation; provision of accommodation and food and drink; information and communication; real estate; professional, scientific and technical activities; arts, entertainment and recreation; and other service activities) 9. Not working
6	Age	-

3.2. Methodology

This study conducts random oversampling and random undersampling Classification and Regression Trees (CART) methods. CART is a method or algorithm of a decision tree technique or classification technique using a binary recursive partitioning algorithm (Lewis et al., 2000). CART produces a classification tree if the response variables used have a classification/ categorical scale. Otherwise, it produces a regression tree if the response variables have a numerical scale (continuous data) (Breiman et al., 1984). In this research, CART will generate a classification tree since the response data used is in the form of categorical data consisting of two categories, namely residents aged 17 years and over accessing the internet for e-banking and not accessing the e-banking.

There are three main stages in forming a classification tree, namely selecting partitions, determining terminal nodes, and marking class labels (Breiman et al., 1984). The first stage is partitioning which is performed at each node, namely determining the possibility of partitioning (s) for each explanatory variable. Each partition depends on the value of an explanatory variable X. If the explanatory variable X_j is continuous, the possible partitions are $X_j < c$, where c is the middle value between the two observed values of the variable X_j respectively. While there will be $n-1$ insulating (s) as X_j has n different observations. If the explanatory variable is categorical with L categories, then there are $2^{L-1}-1$ possible partitions for categorical explanatory variables with nominal scales, while there are as many as $L-1$ possible partitions for categorical variables with ordinal scales.

Node insulation is determined by selecting the insulation that produces the highest heterogeneity reduction using a measure of the impurity value of the Gini index. The Gini index value at node t, $i(t)$, can be written in equation (1).

$$i(t) = 1 - \sum_j p^2(j|t) \qquad (1)$$

where $p(j|t)$ is the probability of the unit of observation in the j^{th} class from node t. The goodness of insulation (s) at node t is defined as the reduction of impurities $\Delta i(s,t)$ which can be written in equation (2).

$$\Delta i(s,t) = i(t) - p_L i(t_L) - p_R i(t_R) \qquad (2)$$

where p_L is the probability of observation at the left node, $i(t_L)$ is the impurity value of the t^{th} left node, p_R is the probability of observation at the right node, and $i(t_R)$ is the impurity value of the right t^{th} node.

The best insulator has the greatest insulator goodness value so that the node is partitioned into two parts, namely the right child node and the left child node. The blocking process is carried out recursively on the two child nodes until they meet certain stopping criteria.

The second stage of insulation is carried out by selecting the final node or terminal node. A terminal node is a node that is no longer insulated by an explanatory variable. A node t will be the final node if it fulfills the criteria that there is no significant heterogeneity in the partitioning of the node, there is only one observation ($n = 1$) in each child node or there is a certain minimum n observation limit (minsplit), and there is a depth level limit. maximum tree (maxdepth). The minimum limit of observations (minsplit) in this study was 90 for the CART random undersampling method and 150 for the CART random oversampling method. While the specified maxdepth is 4. The choice of minsplit and maxdepth is based on the highest accuracy value produced.

The last stage of insulation is carried out by marking class labels. The label of a node is the class j_0 that can maximize $p(j|t)$, (j_0 which satisfies $p(j_0|t) = max_i p(j|t)$. The prior probability used is prior equal so that $p(j|t) = \frac{N_j(t)}{N_j}$, where $N_j(t)$ is the number of class j observations at node t while N_j is the number of class j observations.

The evaluation of CART results uses the balanced accuracy value. Balanced accuracy is one of the benchmarks for assessing the goodness of a model on unbalanced data. The data used to calculate the balanced accuracy is testing data.

After preliminary processing, from the total of 52.955 residents aged 17 years and over in North Sumatra, the percentage who access the internet for e-banking is only 2,62 percent (Table 3). This indicates that there is an imbalance in the number of observations for the categories of the observed response variables.

Table 2
Classification Accuracy

Prediction	Reality	
	Accessing e-banking	**Not accessing e-banking**
Accessing e-banking	A	B
Not accessing e-banking	C	D
Total	A+C	B+D

Sensitivity	A/(A+C)	
Specificity		D/(B+D)
Balanced accuracy	(Sensitivity + Specificity)/2	

$$Balanced\ Accuracy = \frac{Sensitivity + Specificity}{2} \quad (3)$$

The data imbalance may have a negative impact on the classification results where the minority class is often misclassified as the majority class. The minority class is a category that has fewer observations and vice versa. In this case, the minority class is residents aged 17 years and over who access the internet for e-banking, and the majority class is residents aged 17 years and over who do not access the internet for e-banking. Unbalanced data in the preparation of the model needs to be handled so as not to affect the goodness of the resulting model. If the data balance is not met, it may lead to misclassification in the minority category (Jian et al., 2016). The categories generated from the model tend to be the majority group so the contribution of the minority group to the resulting model is very small.

Table 3.
Number and Percentage of Population 17 Years Old and Over Using Banking Facilities (e-Banking) in North Sumatra, 2020

E-Banking Access Status	Number (people)	Percentage (%)
Accessing e-banking	1.390	2,62
Not accessing e-banking	51.565	97,38
Total	52.955	100

This research conducts resampling method to overcome this issue. Resampling is one of the pre-processing techniques in balancing the distribution of data to reduce the effects of an unbalanced distribution of classes or categories (Jian et al., 2016). This research utilizes random oversampling and random undersampling. Random oversampling is used to balance data by increasing the minority class sample by duplicating the minority class sample randomly until the number of observations in the minority class is equal to the number of observations in the majority class (He et al., 2018). Random undersampling is used to balance the data by randomly eliminating the majority class so that the number of observations in the majority class is the same as the number of observations in the minority class (Prusa et al., 2015; Rajesh & Dhuli, 2018).

The resampling process is carried out on the training data used for building the CART. The sample data obtained is divided randomly into two parts, namely 80% training data and 20% testing data. The training data is used to build the model while the testing data is used to test the model by calculating its accuracy.

4. RESULTS AND FINDINGS

This section comprises three subsections. We discuss description statistics of the dependent and explanatory variables in first subsection, followed by the random oversampling and random undersampling CART results in second subsection. The final subsection discusses the model evaluation.

4.1. Description Statistics

Based on the March 2020 SUSENAS sample, the people aged 17 and over in North Sumatra mostly were high school graduates/equivalent, female, married, lived in rural areas, worked in agriculture, had no savings, and did not access e-banking (Appendix 1). Their age was majority around 40 years old (Figure 4).

Three districts/cities in North Sumatra that had the highest percentage of the population aged 17 and over who accessed the internet were Nias Barat (68,49%), Sibolga City (66,62%), and Tapanuli Utara Regency (63,43%). Districts/cities with the highest percentage of population aged 17 years and over accessing e-banking were Sibolga City (9,37%), Medan City (8,29%), and Tapanuli Utara Regency (7,86%) (Appendix 2).

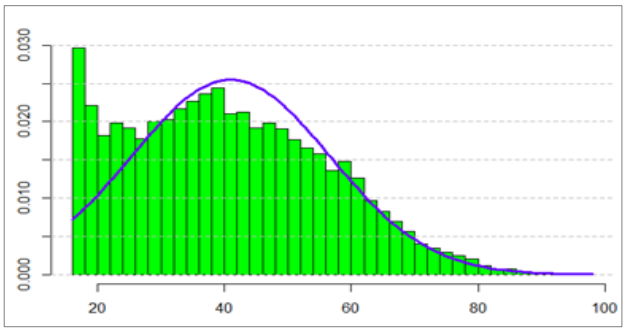

Figure 4.
Respondent's Age Histogram

Table 4 shows the cross tabulation between the individual characteristics of respondents and their status of the accessing the e-banking. It shows that in 2020, most of the people in North Sumatra who accessed the internet for e-banking were dominated by college graduates, male, married, and lived in urban areas. They also mostly worked in the wholesale and retail trade sector.

Table 4.
Percentage of Respondest by E-Banking Access Status and Individual Characteristics in North Sumatra, 2020

Variable	Category	E-Banking Access Status	
		Accessing	Not Accessing
Level of Education	Did not finish elementary school	0,72	14,16
	Graduated from elementary school/equivalent	2,95	18,45
	Graduated from junior high school/equivalent	5,90	21,93
	Graduated from high school/equivalent	38,70	35,86
	Graduated from college	51,73	9,60
Gender	Male	54,39	48,33
	Female	45,61	51,67

Marital Status	Not Married	24,03	23,04
	Married	71,51	65,86
	Divorced	4,46	11,10
Type of Residential Area	Urban	75,83	44,66
	Rural	24,17	55,34
Business Field	Agriculture	7,55	33,58
	Manufacturing	6,04	4,15
	Wholesale and retail trade	17,05	10,04
	Financial activities	5,32	0,42
	Government administration	14,97	2,79
	Education	14,75	3,40
	Human health and social activities	5,40	1,04
	Others	15,61	16,38
	Not working	13,31	28,20

Moreover, based on the age distribution of respondents, the people who accessed the internet for e-banking purpose were younger than those who did not access the internet for e-banking (Figure 5).

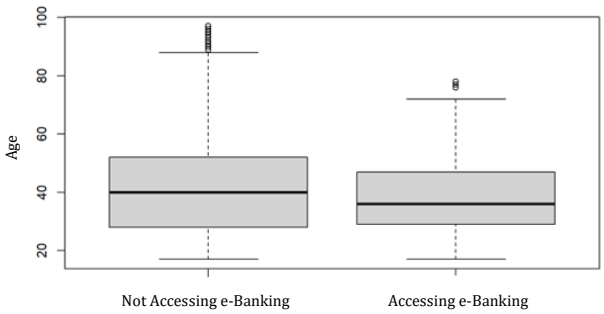

Figure 5.
Boxplot Status of Accessing e-Banking and Age of the Respondents in North Sumatra, 2020

4.2. Random Oversampling and Random Undersampling CART Results

The sample data from the March 2020 SUSENAS in North Sumatra were divided randomly into two parts, namely 80% training data and 20% testing data. The training data was used to construct a classification tree while the testing data was used to test the classification tree that had been formed by calculating the accuracy value of the classification tree. From a sample of 52.955 residents aged 17 years and over in North Sumatra, 80% of the population (42.364 residents) were used as training data, while the remaining residents were used as testing data.

From a total of 42.364 residents aged 17 years and over in North Sumatra on training data, the percentage of those who accessed the internet for e-banking was only 2,62 percent (Table 5). This indicates that there was an imbalance in the number of observations for the categories of response variables.

Table 5.
Number and Percentage of Population 17 Years and Over by Type of Data and Category of e-Banking Use in North Sumatra in 2020

Type of Data	Accessing e-Banking Status		Total
	Accessing e-Banking	Not Accessing e-Banking	
Training data	1.112 (2,62%)	41.252 (97,38%)	42.364 (100%)
Random undersampling of the training data	1.112 (50%)	1.112 (50%)	2.224 (100%)
Random oversampling of the training data	41.252 (50%)	41.252 (50%)	82.504 (100%)

The data imbalance needs to be addressed because it may affect the accuracy of the data classification process (Thanathamathee & Lursinsap, 2013). Unbalanced data handling used is random undersampling and random oversampling. Random undersampling is a sampling process that is carried out by randomly eliminating some of the data in the majority class (category using e-banking). While random oversampling is a sampling process that is carried out by adding the amount of data in the minority class randomly, namely by randomly increasing the number of observations in the category using e-banking from a total of 1.112 observations to 41.252 observations (same as the number of observations in the category not using e-banking). Table 5 shows the total new dataset from random undersampling and random oversampling. There were 2.224 samples of new random undersampling dataset and 82.504 samples of new random oversampling dataset.

Figure 6 is a classification tree obtained from data by a random undersampling process. The variable of education level is the main discriminatory variable to classify people accessing the internet for e-banking. Variables that also play a role in determining the classification of people who access the internet for e-banking are the type of residence area and business field.

The characteristics of people who access the internet for e-banking are as follows:

1. Population aged 17 years and over who graduate from university/equivalent.
2. Population aged 17 years and over with senior high school education level/equivalent and living in urban areas.
3. Population aged 17 years and over with senior high school/equivalent education level, living in rural areas, and working in the sector of manufacturing; financial activities; government administration; education; and human health and social activities.

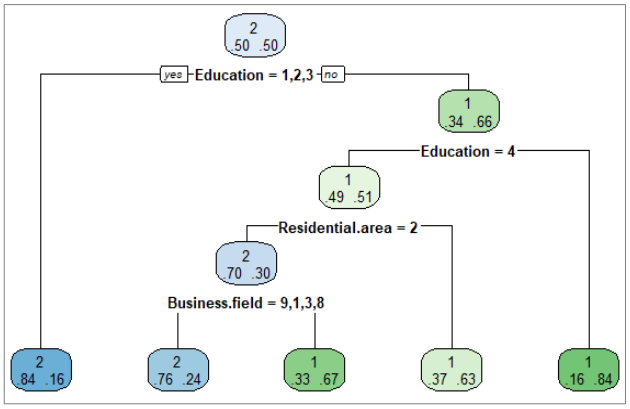

Figure 6.
Random Undersampling Classification Tree

Meanwhile, the characteristics of people who do not access the internet for e-banking are as follows:

1. Population aged 17 years and over with an education level of not completing elementary school or graduated elementary school/ equivalent or graduated junior high school/equivalent.
2. Population aged 17 years and over with senior high school/equivalent education level, living in rural areas, and not working or working in the sector of agriculture; wholesale and retail trade; and others (mining; procurement of electricity, gas, and water; construction; transportation; provision of accommodation and food and drink; information and communication; real estate; professional, scientific and technical activities; arts, entertainment and recreation; and other service activities).

Figure 7 is a classification tree obtained from data by a random oversampling process. The variable of education level is the main discriminatory variable and the most determined variable to classify people who access the internet for e-banking. Variables that also play a role in determining the classification of people who access the internet for e-banking are age, type of residence area, and business field.

The characteristics of people who access the internet for e-banking are as follows:

1. Population aged 17 years and over who graduate from university/equivalent and work in the sector of manufacturing; wholesale and retail trade; financial activities; government administration; education; human health and social activities; and others.
2. Population aged 17 years and over who graduate from university/equivalent, not working or working in the sector of agriculture and living in urban areas.
3. Population aged 17 years and over with senior high school education level/equivalent, living in urban areas, and working in the sector of manufacturing; wholesale and retail trade; financial activities; government administration; education; human health and social activities; and others.
4. Population aged 17 years and over with senior high school/equivalent education level, living in rural areas, and working in the sector of manufacturing; wholesale and retail trade; financial activities; government administration; education; and human health and social activities.
5. Residents with an educational level who did not finish elementary school or graduate from elementary school/equivalent or graduate from junior high school/equivalent, work in the sector of wholesale and retail trade; government administration; and education; and aged between 37 or 38 or 39 years old.

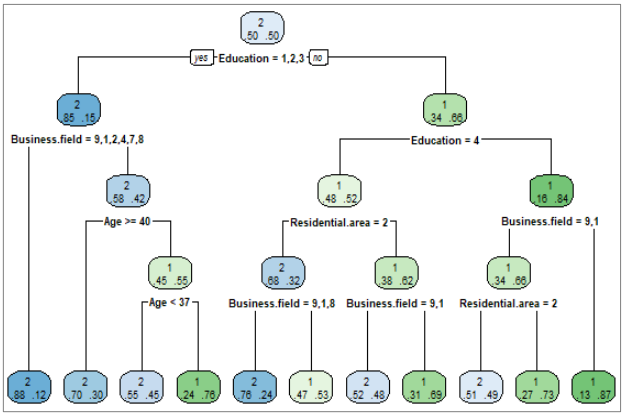

Figure 7.
Random Oversampling Classification Tree

1. Population aged 17 years and over who graduate from university/equivalent, not working or working in the sector of agricultural, and living in rural areas.
2. Residents aged 17 years and over with senior high school/equivalent education level, live in urban areas, and not working or working in the sector of agriculture.
3. Residents aged 17 years and over with senior high school/equivalent education level, live in rural areas, not working or working in the sector of agriculture and others.
4. Residents with an educational level who did not finish elementary school or graduate from elementary school/equivalent or graduate from junior high school/equivalent, work in the sector of wholesale and retail trade; government administration; and education; and aged less than 37 years.
5. Residents with an educational level who did not finish elementary school or graduate from elementary school/equivalent or graduate from junior high school/equivalent, work in the sector of wholesale and retail trade; government administration; and education; and aged more than or equal to 40 years.
6. Residents with an educational level who have not completed elementary school or graduated from elementary school/equivalent or graduated from

junior high school/equivalent, not working or working in the sector of agricultural; manufacturing; financial activities; human health and social activities; and others.

4.3. Model Evaluation

Evaluation of the CART model uses a balanced accuracy value. Balanced accuracy is the average of the sensitivity and specificity values. Calculation of the accuracy value utilizes data testing of 10.591 residents. Table 6 shows the classification accuracy of random undersampling CART.

Table 6.
Classification Accuracy of Random Undersampling CART

Prediction	Reality	
	Accessing e-Banking	**Not Accessing e-Banking**
Accessing e-Banking	241	3.077
Not Accessing e-Banking	37	7.2,36
Total	278	10.313
Sensitivity	241/278=86,69	
Specificity		7.236/10.313= 7016
Balanced accuracy	(86,69+70,16)/2 = **78,425**	

The percentage of people accessing the internet for e-banking correctly predicted that these people accessing the internet for e-banking is 86,69 percent (sensitivity). The percentage of people who do not access the internet for e-banking correctly predicted that these people do not access the internet for e-banking is 70,16 percent (specificity). Therefore, the balanced accuracy resulting from random undersampling CART is 78,425 percent.

Table 7.
Classification Accuracy of Random Oversampling CART

Prediction	Reality	
	Accessing e-Banking	**Not Accessing e-Banking**
Acces e-Banking	215	2.389
Not Accessing e-Banking	63	7.924
Total	278	10.313
Sensitivity	215/278=77,34	
Specificity		7.924/10.313= 76,84
Balanced accuracy	(77,34+76,84)/2 = **77,090**	

While table 7 shows the accuracy for random oversampling of the classification tree. It can be seen that the percentage of people accessing the internet for e-banking purposes correctly predicted that these people accessing the internet for e-banking purposes is 77,34 percent (sensitivity). The percentage of people who do not access the internet for e-banking correctly predicted that these people do not access the internet for e-banking is 76,84 percent (specificity). Thus, the balanced accuracy resulting from random oversampling CART is 77,090 percent.

5. CONCLUSIONS

This research finds the most variable determines the classification of people accessing the internet for e-banking is the level of education. Other variables that also play a role in determining the classification of people who access the internet for e-banking are the type of area of residence and business field.

Random undersampling CART has a balanced accuracy value of 78,425 percent. This value is greater than the value of the balanced accuracy of the random oversampling CART method, which is equal to 77,09 percent. There are three types of characteristics of people who access the internet for e-banking based on the method that provides the greatest balanced accuracy, namely residents aged 17 years and over with a university degree; population aged 17 years and over with a senior high school graduate/equivalent education level and living in urban areas; and residents aged 17 years and over with senior high school/equivalent education level, live in rural areas, and work in sector of manufacturing; financial activities; government administration; education; and human health and social activities.

6. IMPLICATION

Based on the CART results, the recommendation for Bank Indonesia is to prepare promotional media, socialization, and education on CBDC implementation and pays attention to individual characteristics, especially in the people of North Sumatra, as obtained from this study. The results of the study show that the people of North Sumatra who live in urban areas and graduate from senior high school/equivalent will access internet for e-banking. Thus, promotion, socialization, and education of CBDC to population groups living in this area can be prioritized for those with education below senior high school/equivalent. Whereas for groups of people who live in rural areas, the use of e-banking is carried out by residents who have at least graduated from senior high school/equivalent and work in the sector of manufacturing; financial activities; government administration; education; and human health and social activities. Therefore, the target of promoting, socializing and educating CBDC to population groups living in rural North Sumatra is the population with education below senior high school/equivalent, and working not in the sector of manufacturing; financial activities; government administration; education; and human health and social activities.

Bank Indonesia through its representative office in North Sumatra can also collaborate with the North Sumatra regional government (in this case the North Sumatra Bappeda, the North Sumatra Education Office, and the North Sumatra Statistics Communication and Information Office) in designing mechanisms for promotion, outreach, and education to the public. This program can be given from the basic education level

(elementary school/equivalent and junior high school/equivalent) so that the people of North Sumatra can understand the advantages and risks of implementing CBDC.

Acknowledgement

The authors expressed our gratitude to the North Sumatra Province Bank Indonesia Representative Office for selecting this paper to be the finalize of the 3rd SUMATRANOMICS 2022.

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Appendix 1. Percentage of people aged 17 and over in North Sumatra, 2020

Number	Variable Name	Category	Percentage
1	Level of education	1. Did not finish elementary school	13,81
		2. Graduated from elementary school/equivalent	18,04
		3. Graduated from junior high school/equivalent	21,51
		4. Graduated from high school/equivalent	35,93
		5. Graduated from college	10,71
2	Gender	1. Male	48,48
		2. Female	51,52
3	Marital status	1. Not Married	23,07
		2. Married	66,00
		3. Divorced	10,93
4	Type of residential area	1. Urban	45,47
		2. Rural	54,53
5	Business field	1. Agriculture	32,89
		2. Manufacturing	4,20
		3. Wholesale and retail trade	10,23
		4. Financial activities	0,55
		5. Government administration	3,11
		6. Education	3,70
		7. Human health and social activities	1,15
		8. Others	16,36
		9. Not working	27,81

Source: Susenas, March 2020

Appendix 2. Number of Samples, Percentage of Respondents Accessing the Internet, and Percentage of Respondents Accessing e-Banking by District/City in North Sumatra, 2020

Number	District/City	Number of Samples (People)	Accessing the Internet (%)	Accessing e-Banking (%)
1	Nias	1.513	30,93	0,46
2	Mandailing Natal	1.627	35,03	1,04
3	Tapanuli Selatan	1.460	35,34	2,26
4	Tapanuli Tengah	1.576	42,89	0,82
5	Tapanuli Utara	1.591	39,22	1,76
6	Toba Samosir	1.245	53,25	1,37
7	Labuhan Batu	1.698	45,47	3,53
8	Asahan	1.950	45,90	2,05
9	Simalungun	1.867	52,33	2,79
10	Dairi	1.423	50,88	2,11
11	Karo	1.613	48,92	2,29
12	Deli Serdang	2.623	53,83	3,28
13	Langkat	2.104	40,87	0,67
14	Nias Selatan	1.657	29,57	0,24
15	Humbang Hasundutan	1.205	36,02	0,33
16	Pakpak Bharat	1.164	46,31	0,69
17	Samosir	1.261	47,90	3,01
18	Serdang Bedagai	1.905	40,16	1,31
19	Batu Bara	1.601	40,97	2,44
20	Padang Lawas Utara	1.363	33,53	1,61
21	Padang Lawas	1.373	43,48	2,04
22	Labuhan Batu Selatan	1.547	52,29	2,52
23	Labuhan Batu Utara	1.514	42,67	2,31
24	Nias Utara	1.453	31,59	1,03
25	Nias Barat	1.491	31,52	1,07
26	Sibolga City	1.593	68,49	3,01
27	Tanjung Balai City	1.444	50,76	0,83
28	Pematang Siantar City	1.578	63,43	7,86
29	Tebing Tinggi City	1.333	57,09	2,18
30	Medan City	2.648	66,62	9,37
31	Binjai City	1.471	55,81	8,29
32	Padang Sidempuan City	1.493	57,94	3,88
33	Gunung Sitoli City	1.571	47,74	2,67

Source: Susenas, March 2020