

Strategic Expansion of Digital Payments in Papua and West Papua: Individual Character Analysis Using Random Over and Under Sampling CART

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Abstract. This study examines the characteristics and influencing factors of digital payment usage among individuals in Papua and West Papua. Understanding these characteristics enables stakeholders to design effective strategies for promotion, socialization, and education to support the expansion of digital payment adoption. The analysis uses data from the March 2023 National Socio-Economic Survey conducted by BPS, involving 52,081 respondents aged 17 years and older. A Classification and Regression Trees (CART) approach was applied with random oversampling and undersampling techniques to handle data imbalance. The results reveal that business fields, types of residential areas, and education levels are key determinants of digital payment usage. Three primary user profiles were identified: (1) individuals aged 17+ working outside the agricultural sector with at least a high school education; (2) individuals aged 17+ working outside agriculture, with junior high school education or below, residing in urban areas; and (3) individuals aged 17+ working in agriculture or unemployed, living in urban areas, and having completed high school or higher. These findings suggest that stakeholders should tailor promotional strategies and educational programs based on individual characteristics to effectively increase digital payment adoption in Papua and West Papua.

Keyword: Classification and Regression Trees (CART), Digital payments, e-Banking, Resampling

1. Introduction

The digital economy has become one of the key drivers of inclusive and sustainable economic growth. It encompasses all economic activities that rely on or are significantly enhanced by digital technologies, infrastructure, services, and data [1]. The digital economy rests on three essential pillars: technological infrastructure, e-business, and e-commerce [2]. In Indonesia, these pillars have evolved rapidly, particularly since the onset of the COVID-19 pandemic in March 2020. Concerns over virus transmission reshaped consumer behavior, accelerating the shift from offline to online transactions and driving increased reliance on digital financial services.

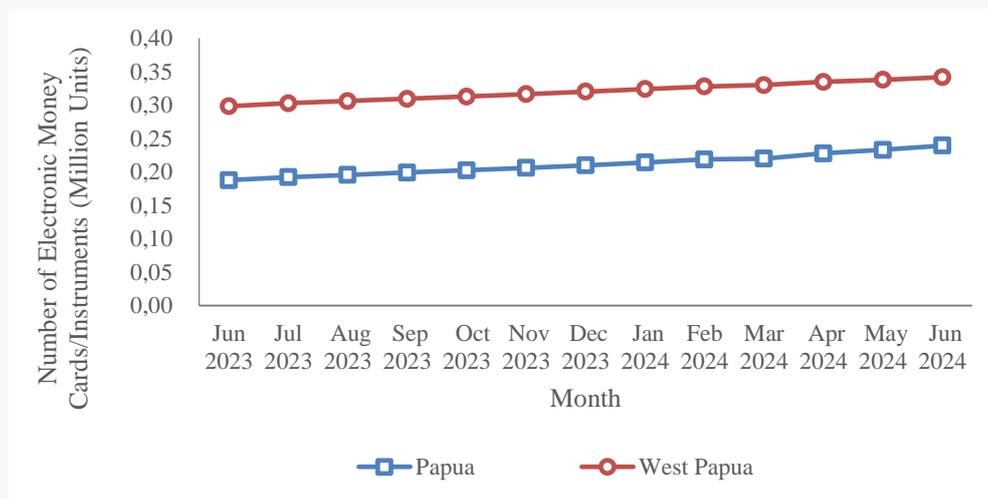
Bank Indonesia reported a significant rise in electronic money transaction volumes in 2020 compared to the previous year, marking a major turning point in the country's financial ecosystem. This growth reflects the growing integration of financial technology (fintech), the combination of innovative technologies and financial services aimed at reducing cash dependency and improving transaction efficiency [3]. Digital payment systems represent an intersection of adaptive technology and innovative



financial solutions, fundamentally transforming both institutional operations and consumer financial behavior [4]. To accommodate these developments, the Indonesian government introduced the National Digital Economy Development Strategy 2023–2030, which outlines six strategic pillars: digital infrastructure, human resource development, business climate and cybersecurity, research and innovation, financing and investment, and regulatory frameworks. Among these, human resource readiness is particularly crucial, as a digitally competent population is essential fully integrate financial technologies into everyday economic activities.

However, the 2021 Digital Skills Gap Index (DSGI) ranks Indonesia 47th out of 134 countries, highlighting persistent gaps in digital literacy and workforce readiness. These challenges directly affect the implementation of digital payment systems, especially in regions where technological infrastructure and financial inclusion remain limited, such as Papua and West Papua.

In 2024, Papua and West Papua have shown positive trends in adopting digital payment systems. Bank Indonesia data indicate steady growth in the issuance of electronic money cards and instruments between June 2023 and June 2024, demonstrating increasing public interest in cashless transactions.



Source: Bank Indonesia

Figure 1. Number of Electronic Money Cards/Instruments (Million Units) in Papua and West Papua, June 2023 – June 2024

As shown in Figure 1, the number of electronic money instruments increased 33% within one year, reflecting growing public acceptance of digital payment technologies. While this growth is encouraging, it also highlights challenges in infrastructure, literacy, and accessibility that must be addressed to accelerate adoption further. To better understand this phenomenon, this study uses data from the March 2023 National Socio-Economic Survey conducted by BPS-Statistics Indonesia. The dataset comprises 53,413 individuals aged 17 years and older in Papua and West Papua. Analysis of this dataset reveals a significant imbalance between individuals who use digital payments and those who do not, as shown in Table 1.



Table 1. Number and Percentage of Population Aged 17 and Above Using Digital Payments in Papua and West Papua, 2023

Population Category	Number	Percentage (%)
Using Digital Payments	1,332	2.49
Not Using Digital Payments	52,081	97.51
Total	53,413	100.00

Table 1 illustrates a highly imbalanced dataset: only 2.49% of individuals aged 17 and above reported using digital payments, while the vast majority (97.51%) have not adopted these technologies. This imbalance poses significant challenges for statistical modeling and machine learning approaches, as conventional classifiers tend to favor the majority class, leading to systematic misclassification of digital payment users. To overcome this problem, this study applies Classification and Regression Trees (CART) combined with random oversampling and random undersampling techniques. CART, introduced by Breiman et al. (1984), is a non-parametric decision tree model capable of handling both classification and regression tasks [5]. In this study, CART is used for binary classification to distinguish between digital payment users and non-users.

Because the dataset is heavily skewed, we implement the following resampling techniques before modeling. Random Oversampling method duplicates observations from the minority class (digital payment users) to increase their representation until it matches the size of the majority class [6]. Random Undersampling method randomly removes samples from the majority class (non-users) until the dataset reaches balance [7]. Using this combined approach ensures that the CART model treats both classes equally, improving predictive performance and allowing for a more accurate analysis of the factors influencing digital payment adoption.

Numerous studies highlight the growing adoption of technologies such as mobile banking, internet banking, and e-wallets due to their ease of use and financial incentives [8], [9]. However, the adoption of digital financial services cannot be explained by technological availability alone. Research by Cheng et al. [10] emphasizes that socioeconomic and demographic characteristics, including age, education, income, and geographic location, significantly influence consumer readiness to adopt digital payments.

In Indonesia, existing research has primarily focused on technological optimization rather than understanding user-specific characteristics. Studies by [11], [12], [13] examine improvements to mobile payment platforms, regulatory monitoring, and blockchain integration for transaction security, respectively. While valuable, these studies provide limited insights into the behavioral and demographic factors shaping adoption patterns. Research by [14], [15], [16] reveals that gender, education, and occupation influence adoption rates. However, these studies primarily examine urbanized regions with stronger infrastructure, leaving a critical knowledge gap in underserved areas like Papua and West Papua, where geographic isolation, infrastructure limitations, and cultural diversity create unique challenges.

This study aims to fill that gap by analyzing individual demographic and socioeconomic characteristics that influence digital payment usage in Papua and West Papua. Specifically, the research seeks to address the following questions:

1. What are the key individual characteristics that influence digital payment adoption in Papua and West Papua?
2. How can these characteristics be used to identify distinct user profiles?
3. What policy implications can be drawn to promote inclusive digital payment adoption in underdeveloped regions?

By addressing these questions, this research contributes both methodologically and practically. Methodologically, it demonstrates how CART with resampling techniques can effectively manage imbalanced data while identifying meaningful classification patterns. Practically, it provides actionable



insights for policymakers, financial institutions, and fintech providers. The findings can guide the design of targeted outreach, educational, and promotional programs; support resource allocation for digital infrastructure; and inform evidence-based policy interventions that strengthen financial inclusion across Indonesia's eastern regions.

Ultimately, this study contributes to Indonesia's broader digital economy transformation by providing empirical evidence that can help close adoption gaps, optimize digital payment ecosystems, and design regionally adaptive strategies that align with the needs and readiness of diverse populations.

2. Research Method

This research uses data sourced from the March 2023 National Socio-Economic Survey for Papua and West Papua (prior to the establishment of new autonomous regions), conducted by the BPS-Statistics Indonesia. The unit of analysis used in this research is Papua and West Papua residents aged 17 years and above. The total sample used is 52,081. The response variable in this study is the status of digital payment usage, proxied by whether individuals use the internet for banking transactions (e-banking), where code 1 is uses digital payments and code 2 is does not use digital payments. In this context, using digital payments refers to conducting electronic financial transactions via banking services (e-banking). The explanatory variables and their conceptual definitions are presented in Table 2.

Table 2. Explanatory Variables

Number	Independent Variables	Category Codes	Concept and Definition
1	Education Level	1. Did not finish elementary school 2. Completed elementary school/equivalent 3. Completed junior high school/equivalent 4. Completed senior high school/equivalent 5. Graduated from College	The highest educational attainment completed by the respondent, proven by a diploma or certificate.
2	Genders	1. Male 2. Female	The gender of the respondent.
3	Marital Status	1. Married 2. Never married/divorced	Marital status of the respondent at the time of the survey. <i>Married</i> refers to individuals living as a couple under legal, customary, or religious norms, regardless of formal documentation. <i>Divorced</i> includes those separated or widowed and not remarried.
4	Type of Residential Area	1. Urban 2. Rural	Classification of the respondent's village/subdistrict into urban or rural areas.
5	Employment Sector / Field of Work	1. Agriculture 2. Mining & Quarrying 3. Manufacturing 4. Wholesale & Retail Trade, Vehicle Repair 5. Construction 6. Public Administration, Defense & Social Security 7. Education	The primary economic activity where the respondent spent the most time in the last week. If time is equal across activities, the sector generating the highest income is chosen.



		8. Accommodation & Food Services	
		9. Other sectors	
		10. Not working	
6	Age	-	Respondent's age in years, rounded down to the nearest whole year based on the last birthday.

This study employs both, descriptive analysis and inferential modeling. Descriptive analysis is used to present a general overview of the socioeconomic conditions in Papua and West Papua and to illustrate the characteristics of individuals using digital payments proxied by access to the internet for banking transactions (e-banking). Data visualization techniques include tables, bar charts, histograms, and boxplots.

For deeper analysis, we apply the CART method combined with random oversampling and random undersampling techniques. As mentioned earlier, the share of residents in Papua and West Papua using digital payments proxied by internet banking usage is only 2.49% (1,332 people), while the remaining 97.51% (52,081 people) do not use digital payments. This results in a severe class imbalance in the dataset, as shown in Table 1. This imbalance can significantly reduce classification accuracy since models tend to bias toward the majority class. To address this, the study applies resampling techniques (random oversampling and random undersampling). Both techniques are applied only to the training dataset to construct the CART model. The dataset from the March 2023 National Socio-Economic Survey is split into 80% training data and 20% testing data. The training data are used to build the classification model, while the testing data are used to evaluate performance using balanced accuracy.

CART is a binary recursive partitioning algorithm used for classification and regression (Lewis et al., 2000). If the response variable is categorical, CART produces a classification tree; if it is numerical, it produces a regression tree [5]. In this study, the response variable, digital payment usage, is categorical, so the model produces a classification tree. CART identifies key predictor variables and splits the dataset into homogenous groups, enabling precise profiling of digital payment users in Papua and West Papua.

To evaluate the CART random undersampling and oversampling model using balanced accuracy values. Balanced accuracy is one of the benchmarks for assessing the goodness of a model on unbalanced data. The data used in calculating balanced accuracy values is testing data.

3. Results and Discussion

Based on the March 2023 National Socio-Economic Survey sample, the majority of the population aged 17 years and above in Papua and West Papua exhibit low educational attainment (did not finish elementary school), are predominantly male, married, and reside in rural areas, most work in the agricultural sector and do not conduct digital payment transactions (Table 3).

Table 3. Demographic Characteristics of Respondents in Papua and West Papua, March 2023

Number	Variables	Category	Percentage (%)
1	Education Level	1. Did not finish elementary school	29.84
		2. Completed elementary school/equivalent	16.43
		3. Completed junior high school/equivalent	17.97
		4. Completed senior high school/equivalent	26.76
		5. Graduated from College	9.00
2	Genders	1. Male	51.09
		2. Female	48.91
3	Marital Status	1. Married	65.67



		2. Never married/divorced	34.33
4	Type of Residential Area	1. Urban	20.32
		2. Rural	79.68
5	Employment Sector / Field of Work	1. Agriculture	51.46
		2. Mining & Quarrying	0.47
		3. Manufacturing	1.02
		4. Wholesale & Retail Trade, Vehicle Repair	4.78
		5. Construction	1.67
		6. Public Administration, Defense & Social Security	5.55
		7. Education	2.18
		8. Accommodation & Food Services	0.94
		9. Other sectors	4.98
		10. Not working	26.95
6	Digital Payment Status (e-Banking)	1. Uses Digital Payments	2.49
		2. Does Not Use Digital Payments	97.51

As Table 3 shows, rural and agricultural characteristics dominate the population structure, which corresponds to low levels of digital payment adoption in the region. An analysis by employment sector reveals that individuals working in public administration, defense, and social security have the highest proportion of digital payment usage (27.78%). In contrast, over half of non-users (52.71%) are employed in agriculture (Figure 2).

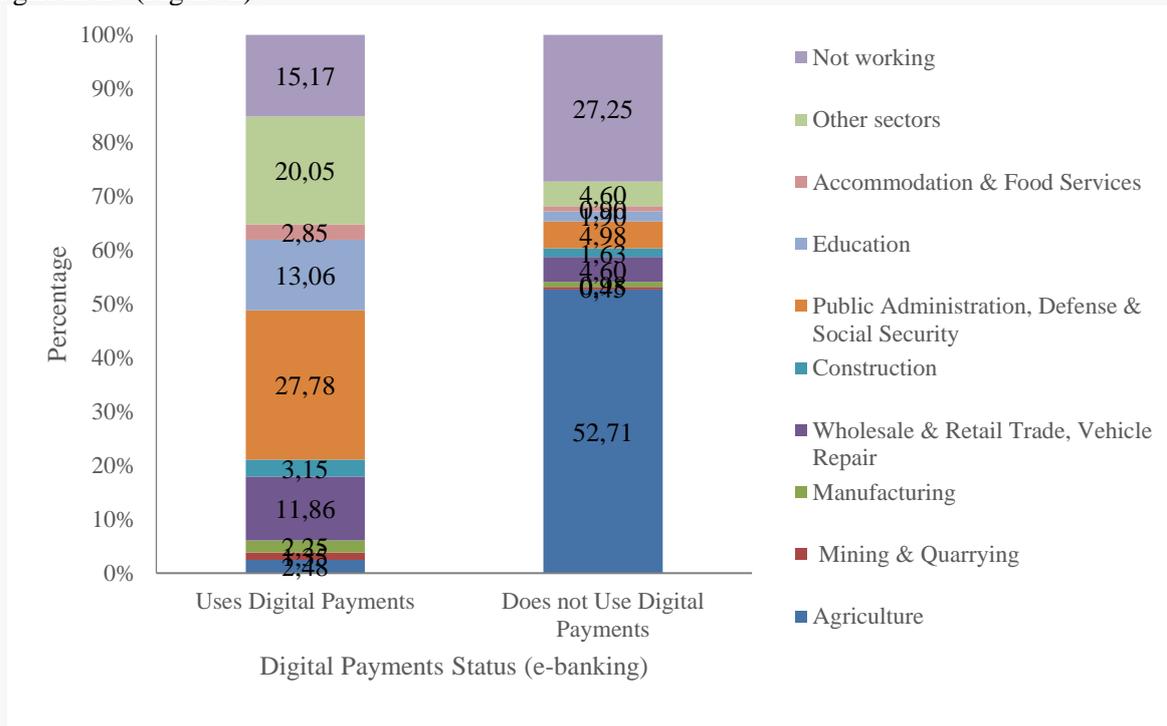


Figure 2. Percentage of Respondents by Digital Payment Usage Status and Employment Sector/Field of Work in Papua and West Papua, March 2023

Digital payment adoption is also strongly associated with urbanization and education level. Most users live in urban areas (75.08%), whereas the majority of non-users (81.08%) reside in rural areas (Figure 3). In terms of education, 47.82% of users are college graduates, while 30.56% of non-users did not complete elementary school (Figure 4).

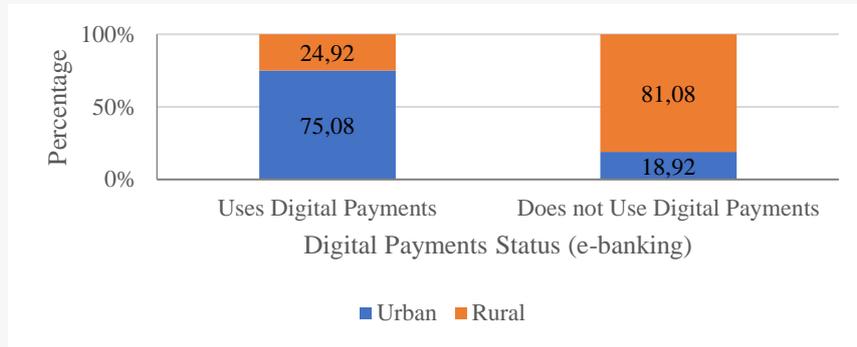


Figure 3. Percentage of Respondents by Digital Payment Usage Status and Type of Residential Area in Papua and West Papua, March 2023

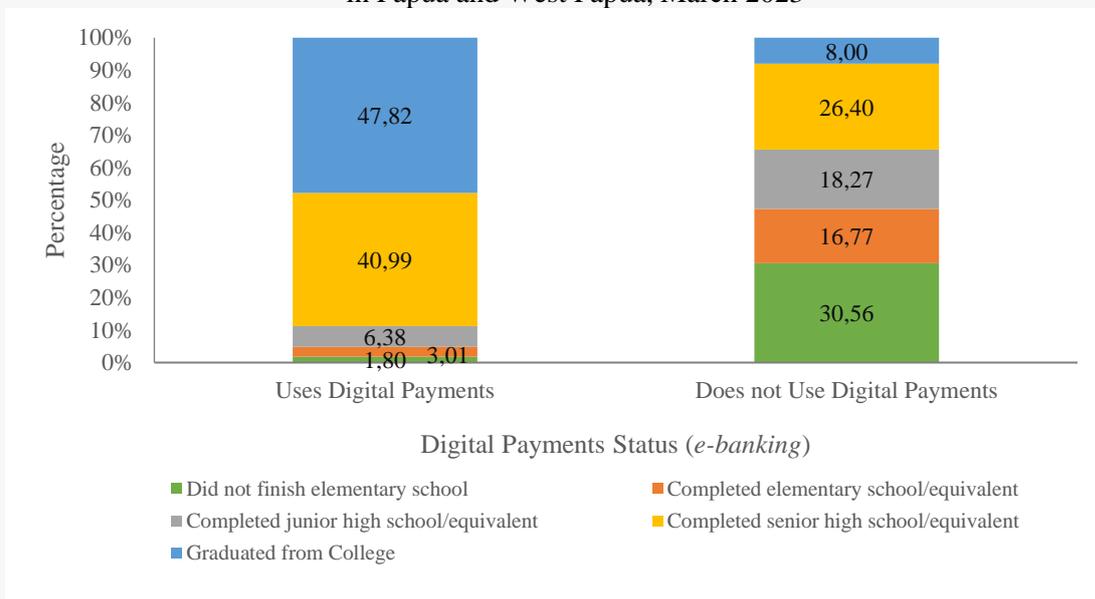


Figure 4. Percentage of Respondents by Digital Payment Usage Status and Education Level in Papua and West Papua, March 2023

The factors that influence the Classification of Digital Payment Users are explained through the results of CART random undersampling and random oversampling. Figure 5 presents the classification tree generated using the random undersampling process. The employment sector emerged as the most important variable in classifying digital payment users, followed by type of residential area.

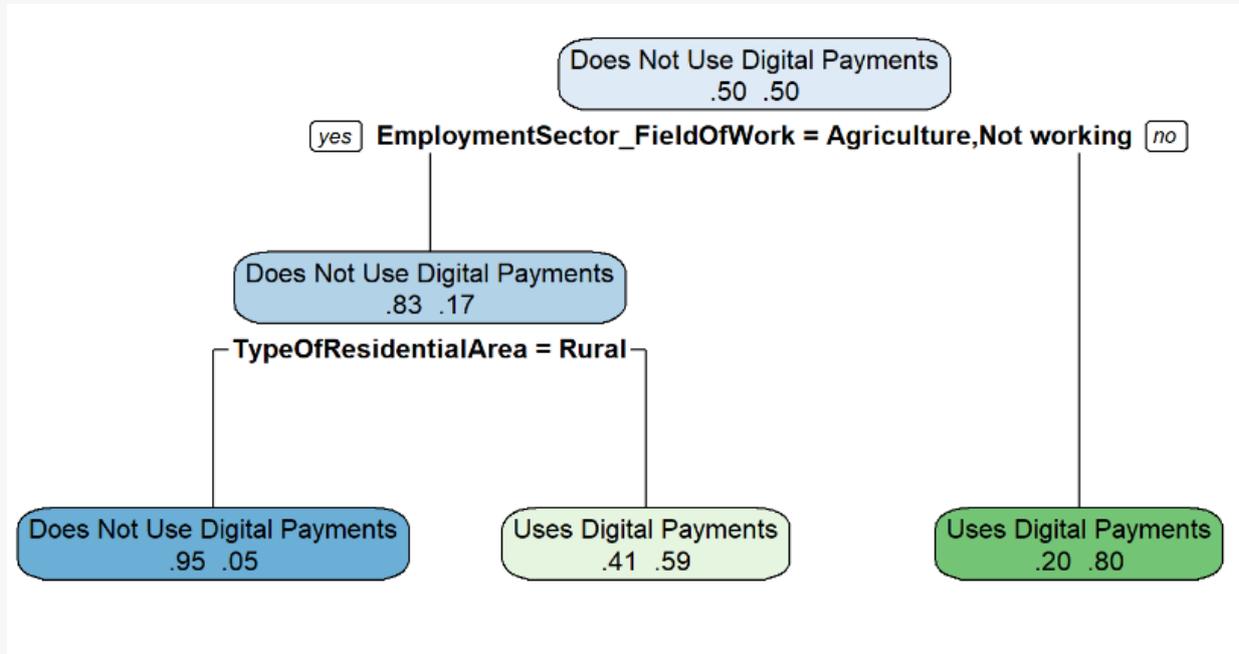


Figure 5. The Classification of Digital Payment Users using Random Undersampling Classification Tree

The characteristics of individuals who use digital payments are as follows:

- 1) Residents aged 17 years and above who work in sectors other than agriculture;
- 2) Residents aged 17 years and above who work in the agricultural sector or are unemployed but live in urban areas.

The characteristic of individuals who do not use digital payments is residents aged 17 years and above who work in the agricultural sector or are unemployed and live in rural areas.

Figure 6 displays the CART model trained with random oversampling. Similar to the previous model, employment sector remains the strongest classifier, followed by education level and residential area.

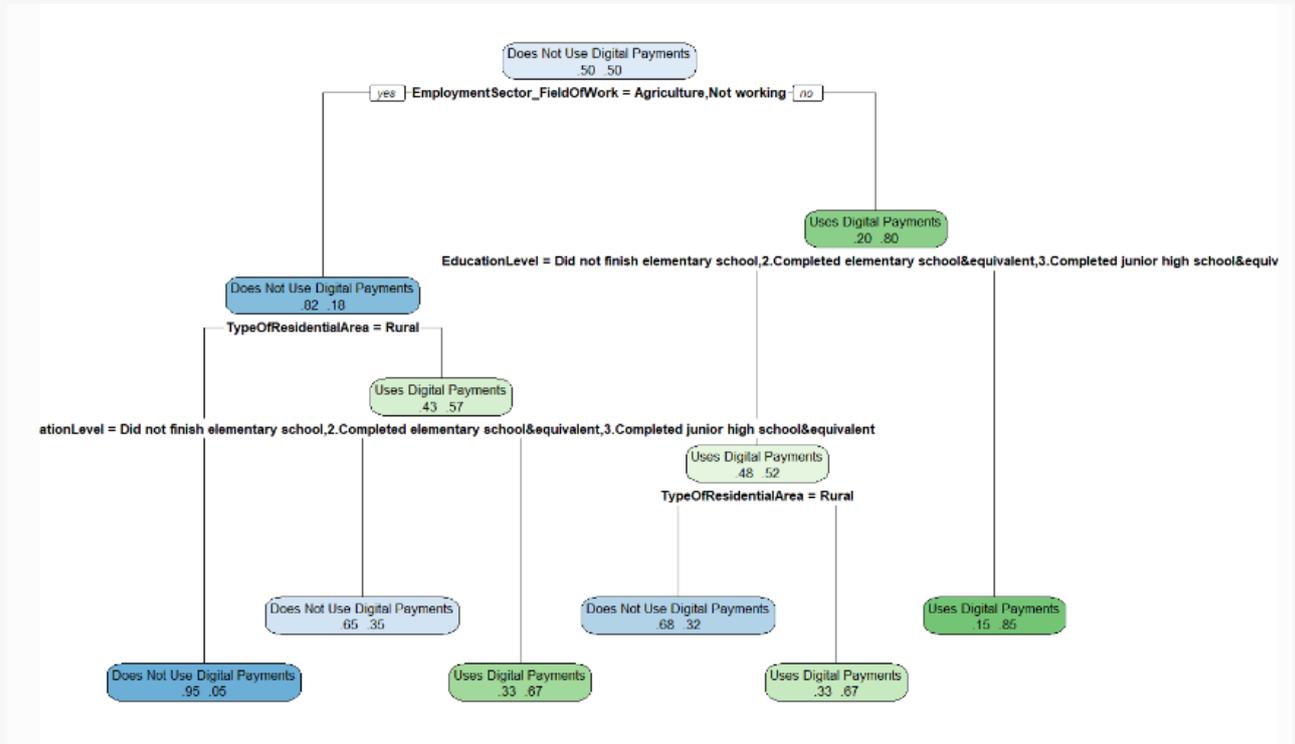


Figure 6. The Classification of Digital Payment Users using Random Oversampling Classification Tree

The characteristics of individuals who use digital payments are as follows:

- 1) Residents aged 17 years and above who work in sectors other than agriculture and have completed senior high school or higher;
- 2) Residents aged 17 years and above who work in sectors other than agriculture, have completed junior high school or below, and live in urban areas;
- 3) Residents aged 17 years and above who work in the agricultural sector or are unemployed, live in urban areas, and have completed senior high school or higher.

The characteristics of individuals who do not use digital payments are as follows:

- 1) Residents aged 17 years and above who work in sectors other than agriculture, have completed senior high school or below, and live in rural areas;
- 2) Residents aged 17 years and above who work in the agricultural sector or are unemployed, live in urban areas, and have completed junior high school or below;
- 3) Residents aged 17 years and above who work in the agricultural sector or are unemployed and live in rural areas.

Evaluation of the CART random undersampling and oversampling model using balanced accuracy values. The data used to calculate balanced accuracy is testing data. The balanced accuracy value of CART random undersampling in predicting digital payment users category is 83.73 percent. The Balanced Accuracy value of CART random oversampling in predicting the digital payment users category was 84.88 percent. This balanced accuracy value is bigger than the balanced accuracy value of CART random undersampling.

The results from CART confirm that employment sector, education, and urban–rural residence are the key determinants of digital payment adoption. Individuals working in government and



service industries have higher digital literacy and financial exposure, while rural agricultural workers remain less engaged in digital finance.

From a cultural perspective, the slower adoption in Papua and West Papua can also be linked to traditional transaction habits, limited trust in digital systems, and language barriers in financial education materials. Technologically, network coverage and inconsistent electricity supply remain persistent obstacles that limit daily digital transactions. These socio-cultural and infrastructural constraints highlight that digital payment adoption is not only a technological issue but also a behavioral and contextual one.

The identification of three user profiles provides practical value for policy and implementation. Targeted strategies such as localized digital literacy training, community-based promotion, and collaboration with local institutions could help accelerate inclusion.

The findings suggest that efforts to expand digital payment adoption should focus on improving access and trust among rural and low-education populations. Bank Indonesia and local governments could collaborate to introduce simplified mobile payment interfaces, vernacular-language tutorials, and awareness programs tailored to local cultural contexts. Enhancing digital infrastructure in rural areas is equally essential to sustain long-term adoption.

Overall, the CART model provides empirical evidence that demographic and geographic segmentation can inform targeted interventions for inclusive digital transformation in Papua and West Papua.

4. Conclusion

The majority The most influential variable in classifying individuals who use digital transactions is the employment sector. Another variable that also plays a significant role in determining the classification of digital transaction users in both the random undersampling CART and random oversampling CART methods is the type of residential area. Additionally, in the random oversampling CART method, education level emerges as an additional variable that contributes to determining the classification.

The random undersampling CART model achieves a balanced accuracy of 83.73%, while the random oversampling CART method provides a slightly higher balanced accuracy of 84.88%. Based on the method with the highest balanced accuracy, the characteristics of individuals who tend to use digital transactions are residents aged 17 years and above who work in sectors other than agriculture and have completed senior high school or higher, residents who work in non-agricultural sectors but have completed junior high school or below and live in urban areas, and residents who work in the agricultural sector or are unemployed but live in urban areas and have completed senior high school or higher.

Based on the CART results discussed earlier, the recommended strategy to expand digital payment adoption is to prepare promotional media, socialization campaigns, and educational programs tailored to individual characteristics, particularly in Papua and West Papua. The findings indicate that residents who work in the agricultural sector or are unemployed, live in urban areas, and have education levels up to senior high school or below are less likely to use digital payments. Therefore, promotion, outreach, and educational programs in urban areas should prioritize these groups to increase awareness and adoption.

In rural areas, residents who do not use digital payments are mostly those working in the agricultural sector or in non-agricultural sectors but with educational attainment up to junior high school or below. Thus, in rural Papua and West Papua, targeted campaigns should focus on individuals with lower levels of education, particularly those in both agricultural and non-agricultural sectors with a maximum of junior high school completion.

Bank Indonesia, through its representative offices in Papua and West Papua, can collaborate with local governments, including Bappeda, the Regional Office of Manpower and Transmigration, and the Regional Office of Education, to design effective mechanisms for promotion, socialization, and education on digital payments. These programs can be introduced at an early stage, starting from



elementary school/equivalent and junior high school/equivalent levels, to help the community better understand the benefits and potential risks of adopting digital payments. Ultimately, increasing awareness and knowledge across all segments of society will encourage broader usage of digital payments and accelerate their expansion in Papua and West Papua. However, these efforts must also be supported by the development of adequate digital infrastructure to ensure accessibility and sustainability.

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