Impact Evaluation of Digitalisation and Pre-Employment Card on The Economy of West Papua

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ABSTRACT

West Papua can serve as a best practice for eastern Indonesia in fostering structural transformation in national development post-Covid-19. With the highest economic growth rate (20.80 per cent) in 2024, the province has also reported an increase in the literacy of the productive-age population in information and communication technology (ICT). Nonetheless, West Papua's digital competitiveness remains relatively low, coupled with substantial challenges in transitioning the young workforce into employment or further education, as reflected in the escalating numbers of individuals classified as Not in Employment, Education, or Training (NEET). This study seeks to examine the impact of digitalisation on economic improvement within the community and evaluate the effectiveness of the pre-employment card program in facilitating job opportunities for youth in West Papua. Employing data from the August 2021–2022 National Labour Force Survey (Sakernas) and the 2021 Village Potential Survey, the analysis utilized Instrumental Variables (IV) Two-Stage Least Squares and Propensity Score Matching (PSM) econometric methods. The results indicate a strong positive association between digitalisation and individual income, with substantially higher earnings among digitally engaged workers, conditional on observable characteristics and instrument validity assumptions. Furthermore, the PSM analysis reveals that the pre-employment card program significantly increases employment opportunities for young individuals, emphasizing the need for continued governmental support in technology access and program benefits.

Keywords: Digitalisation; Pre-Employment Card; Instrumental Variables; Propensity Score Matching.

Introduction

Eastern Indonesia should be repositioned not as a historically marginalized region but as a vital component of the national development strategy. This shift in perspective necessitates that the government pursue a balanced approach to development acceleration through targeted policies, particularly in the areas of infrastructure expansion and human resource development, aimed at enhancing regional economic capacities. In this context, the West Papua province serves as an exemplary model, showcasing the potential for structural transformation in national development. Notably, West Papua has achieved the highest economic growth rate in the country, soaring to 20.80 percent in 2024, significantly surpassing the national average growth rate of 5.03 percent (BPS West Papua, 2025a).

West Papua's economic structure is predominantly anchored in the manufacturing sector, bolstered significantly by the micro and small industry subsector. This crucial

sector encompasses the majority of Micro, Small, and Medium Enterprises (MSMEs), which are instrumental in fostering regional economic growth and are the primary contributors to the Gross Regional Domestic Product (GRDP) of West Papua. Over the past decade, the contribution of the manufacturing sector to the region's GRDP has demonstrated a notable upward trajectory, rising from 30.28 percent in 2013 to an impressive 35.69 percent (BPS West Papua, 2025b).

In addition, the province has made notable improvements in increasing digital literacy, particularly among its working-age population. Over the last five years, the proportion of individuals with ICT skills has increased by nearly 14 percentage points, from 59.45% in 2020 to 73.44% in 2024 (Figure 1). This rise in digital skills signals a potential shift toward a more digitally driven economy, which could complement the growth of MSMEs and open new avenues for economic development. However, despite these advancements in digital literacy, the broader transformation toward a digital economy has not yet reached its full potential.
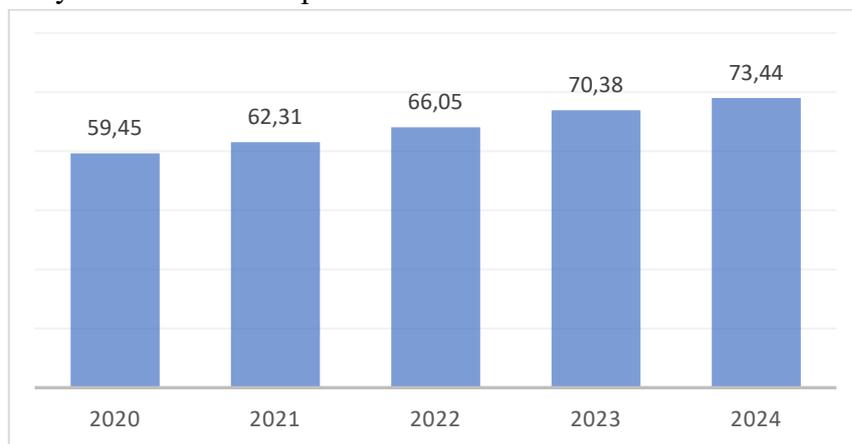
Source: BPS (2024b)

Figure 1.
Proportion of 15-59 Year Olds with Information and Computer Technology (ICT) Skills in West Papua 2020-2024

A recent report from *East Ventures* (2024) highlights a concerning trend in West Papua's Digital Competitiveness Index (DCI). In 2022, the province recorded a DCI score of 34.3, positioning it 19th in national rankings. However, by 2024, this score had decreased to 32.6, resulting in a drop to 30th place nationally. This situation presents a notable paradox: despite an increasing percentage of ICT-literate individuals within the working-age population, West Papua's overall digital competitiveness remains strikingly low.

One clear sign of the sluggish digital transformation in West Papua is the poor uptake of digital technologies within the manufacturing sector. Recent data from 2023 reveals that merely 2.14 percent of the population aged 10 and older had accessed the internet in the preceding three months. This statistic underscores the limited digital advancement in a sector that serves as the backbone of the region's economy. Additionally, the adoption of e-commerce among businesses, particularly MSMEs,

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remains alarmingly low. Only about 20.72 percent of businesses have embraced e-commerce, relegating West Papua to the status of having the fourth-lowest e-commerce adoption rate across the nation (BPS, 2025).

Digitalisation has become an essential requirement for enhancing operational efficiency, business productivity, and the sustainability of MSMEs, especially in the aftermath of the Covid-19 pandemic. The pandemic caused significant economic disruption due to challenges on both the demand and supply sides. However, it also brought about some positive changes. Specifically, Covid-19 acted as a catalyst for accelerating digital transformation across various sectors of the economy.

This shift has transitioned economic activity from traditional face-to-face (offline) interactions to those facilitated by information and communication technology (online). As a result, businesses can continue operating by using the internet to promote their products and conduct online transactions. Additionally, for household-scale businesses that are often labor-intensive, leveraging digital technology not only opens up access to broader markets but also creates opportunities to add value, enhance competitiveness, and foster a more inclusive local economic transformation.

From another perspective, examining the labor supply's role in supporting the economy of West Papua reveals some concerning trends. According to data from the Statistics of West Papua Province (BPS Papua Barat), the open unemployment rate (TPT) has shown a decline, decreasing from approximately 5.84 percent in 2021 to 4.1 percent in 2024. However, this improvement is overshadowed by a significant increase in the number of young individuals classified as NEET (Not in Education, Employment, or Training). The NEET rate escalated from 22 percent in 2021 to nearly 27 percent in 2024. This increase underscores a pressing challenge in facilitating the successful transition of youth into the workforce or further educational opportunities. It reflects significant barriers that hinder many young people from achieving career advancement through access to decent employment and quality training programs.
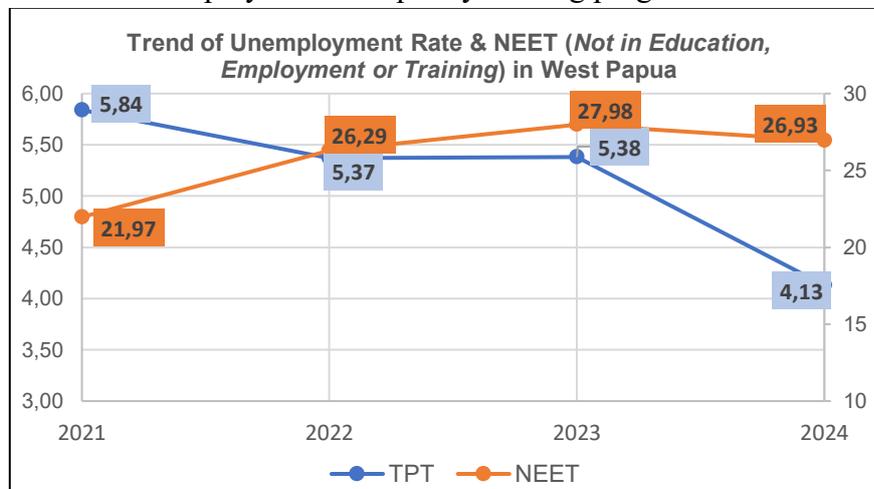
Source: BPS West Papua (2024b)

Figure 2.
Trend of Unemployment Rate & NEET (*Not in Education, Employment or Training*) in West Papua

In response, the Indonesian government launched the Pre-Employment Card program in 2020 to strengthen the national workforce, including in West Papua province. This program was intended as an intervention in the active labor market to enhance skills, digital competencies, and job readiness among the productive-age population (Vooren et al., 2019). Unfortunately, there is no empirical evidence demonstrating the effectiveness of the Pre-Employment Card program on labor market dynamics or its direct impact on the well-being of the people in West Papua.

Based on the above review, this study identifies a significant research gap regarding the impact of digital transformation, specifically the heightened digitalisation experienced in the post-Covid-19 era, on the economic improvement of communities in West Papua. Additionally, it highlights the need to evaluate the effectiveness of the Pre-Employment Card program for young people in creating job opportunities in the region. This gap is particularly crucial, as there is a scarcity of comprehensive studies that address the interplay between digitalisation and the Pre-Employment Card program in relation to economic conditions in West Papua.

The findings from this research are anticipated to not only contribute to the existing body of literature but also provide valuable insights for stakeholders in the formulation of targeted and evidence-based policies. By enhancing economic capacity and elevating the quality of the West Papuan workforce in the context of rapid digital transformation, this study aims to foster sustainable development in the region. Such contributions are vital for addressing the unique challenges faced by West Papua in today's increasingly digital economy.

Literature Review

Contemporary regional economic development strategies can no longer depend exclusively on traditional approaches. Advancing disruptive innovations has become essential, as these mechanisms reshape production processes for goods and services and facilitate the transition from conventional business models to more modern and adaptive systems. Consistent with this perspective, Christensen et al. (2015) argue in their disruptive innovation framework that individuals who effectively leverage disruptive change through enhanced digital competencies are likely to obtain greater benefits and attain higher levels of welfare than those who remain resistant to such developments.

Extensive research has examined the extent to which disruptive innovations, particularly digitalisation and online training, affect economic performance. These elements are regarded as critical determinants in strengthening the capacity of workers and entrepreneurs to remain competitive in an increasingly dynamic economic environment. Empirical findings across a range of studies tend to converge, indicating that optimal utilisation of digital technologies and training initiatives is associated with notable improvements in income and individual performance. Nonetheless, these outcomes remain contingent on various constraints, including geographical characteristics and the adequacy of supporting infrastructure.

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Studies by Rakhmawan (2022) and Falentina (2019) demonstrate that digitalisation, reflected through higher levels of internet adoption, positively contributes to increased business revenues. In addition, Papadopoulos et al. (2020) and Vargo et al. (2021) contend that digitalisation not only supports business continuity during periods of crisis but also creates opportunities for enhanced efficiency and broader organisational growth.

At the regional level, Capello et al. (2023) and Du (2025) show that digitalisation stimulates economic agglomeration in urban centres, subsequently generating positive spillover effects in adjacent areas. Nevertheless, Tranos (2013), observes that although the internet has substantially influenced economic activities, it has not fully detached them from geographical constraints. The expansion of digitalisation may, in fact, produce new forms of spatial disparity, wherein economically central regions, characterised by strong infrastructure and well-developed digital ecosystems, continue to advance, while areas with limited connectivity face increasing marginalisation.

Assessing the impact of digitalisation, operationalised through increased digital adoption, on income requires careful empirical consideration, particularly due to potential endogeneity concerns that arise when inferring causal relationships. Consequently, a growing body of literature examines these relationships by using instruments, such as signal availability. Several studies suggest that signal availability may exert income effects beyond digitalisation. Bahia et al. (2021) argue that mobile broadband rollout influences labor-market outcomes through improved job matching and mobility, even where measured digital usage remains limited. Similarly, Duvivier (2019) finds that broadband availability shapes firm location decisions, implying direct spatial and investment channels.

In contrast, while it seems that signal presence may also directly influence income, evidence that signal coverage drives digital adoption and that digital adoption increases income is strong in the literature. Using cross-country instrumental variable strategies, Czernich et al. (2011) demonstrate that broadband expansion raises economic performance through increased internet use rather than through direct infrastructure effects. Micro-level evidence reinforces this mechanism. Falentina et al. (2021), exploiting exogenous variation in cellular signal strength among Indonesian micro and small enterprises, show that stronger signal coverage increases internet use, which in turn enhances labour productivity, export participation, and firm income, with no direct income effect attributed to signal presence itself. Consistently, Leng (2022) finds that improved connectivity raises rural household income by facilitating participation in digital markets and information flows. Together, these studies provide empirical support for treating digitalisation as the primary mediating channel linking internet signals to income outcomes.

The second regional economic factor concerns the enhancement of community capacity through training initiatives, exemplified by the Pre-Employment Card program. This program represents a governmental intervention in the labour market aimed at improving work competencies and entrepreneurial skills by providing training

scholarships (Kemenko Perekonomian, 2022). Empirical evidence indicates that the program has contributed to increased participant income and has helped reduce unemployment by fostering the establishment of new business ventures (Al Ayyubi et al., 2023).

Moreover, evidence from Presisi Indonesia (2021), Alatas et al. (2021) and Tasmilah (2023) indicates that participants in the Pre-Employment Card program exhibit a higher likelihood of securing employment or establishing their own enterprises compared with non-participants. Research by Satriawan et al. (2022) also reports that most beneficiaries reported positive assessments of the training they received. Nevertheless, to the best of the author's knowledge, no study has specifically examined the program's actual impact on community welfare within the context of West Papua.

Accordingly, this study seeks to address the existing gap in the literature by examining the effects of digitalisation exposure and the Pre-Employment Card program on the economic conditions of communities in West Papua. The research offers an added contribution through the application of analytical approaches such as instrumental variables and propensity score matching, which have not been extensively employed in prior studies on this topic. In addition, the findings are expected to provide a baseline for future evaluations of the program's influence on employment opportunities for residents of West Papua.

Research Methods
Data Source

This study draws on multiple cross-sectional data sources regularly produced by BPS, specifically the National Labor Force Survey (Sakernas) for August 2021 and 2022, as well as the 2021 Village Potential Survey (Podes). The Sakernas survey has long served as a critical and dependable tool for capturing the demographic and employment dynamics of the Indonesian population in a comprehensive manner.

The Sakernas datasets for August 2021 and 2022 were selected due to their strategic timing, aligning with the early phase of economic recovery following the Covid-19 pandemic and the government's removal of the Community Activity Restrictions (PPKM). This period also allows for a clearer assessment of digitalisation effects, as exposure to digital technologies was expected to rise while social activities, such as work, schooling, training, and other interactions, had not yet fully returned to pre-pandemic conditions. The Podes 2021 data serve as complementary information in the analysis, particularly for identifying the availability of digital infrastructure, including 4G/LTE signal coverage at the village level.

This study employs two primary dependent variables to assess the economic conditions of the population in West Papua. Each variable is examined using an estimation strategy aligned with the analytical objectives: 1) *Total income (ln_income)*, encompassing monetary and in-kind earnings received by individuals who are employed, self-employed, or assisting in family business. 2) *Employment status of the young population (Employment),* which reflects the probability to which youth

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participate in income-generating or income-supporting economic activities through employment, self-employment, or assistance in business operations. Furthermore, the study defines the young population as individuals belonging to Generation Y or Millennials (1981–1996) and Generation Z (1997–2012), following the generational categories outlined by William H. Frey (2020). This classification is applied to capture variations in characteristics and behavioural responses across age cohorts, particularly in relation to digital transformation.

To deepen the analysis, this study also investigates worker transitions by assessing differences in the proportions of more prosperous (thriving) and less prosperous (struggling) workers in West Papua following their exposure to digitalisation in the workplace. This component draws on the August 2021 and August 2022 Sakernas datasets, which were matched using sociodemographic characteristics while incorporating patterns of internet usage. The matching procedure was implemented to construct a dataset that approximates a household panel within the Sakernas framework, thereby enabling a more accurate comparison of worker transitions. The final sample consists of 5,232 pooled observations from the 2021 and 2022 surveys.

Operational Definition

Table 1. below explains the operational definitions of the variables used in constructing the research model. This study adopts the independent variables as used in the study by Tasmilah (2023), Noja et al. (2022) Diallo & Goyette (2016), while the dependent variable follow research conducted by Rakhmawan (2022) and Falentina (2019).

Table 1.
Operational Definition of Research Variables

Variable Name	Operational Definition
Dependent Variable	
Total_income (*y_ln_income*)	The amount of income (including money and goods) earned during a month by someone involved in economic activity (employment, self-employment or assisting in business)
Employment status of the young population (y_employment)	Employment status of young people (Gen Y/ Millenials & Gen Z), whether employed, self-employed or helping with business in the last week (employed) Value 1 = if working (*employed*) Value 0 = if not working (*unemployed*)

Variable Name	Operational Definition
Worker welfare	Value 1 (prosperous/thriving) = if income is greater than the West Papuan minimum wage or better than in February 2020. Value 0 (less prosperous/struggling) = if income is less than the West Papuan minimum wage or not better than in February 2020.
Main independent variable / *Variable of interest*	
Digitalisation (x_digitalisation)	A variable indicating the extent of digital media and internet utilisation in the workplace Value 1 = engage in digitalisation Value 0 = if absence digitalisation
Pre-Employment Card (x_kartu_prakerja)	Participation in the Pre-Employment Card program is defined as an individual being registered and having completed the training provided through the program, including those who have received associated benefits. Value 1 = receive benefits of Pre-Employment Card Value 0 = not receive benefits of Pre-Employment Card
Instrument Variable	
4G/LTE Signal Availability (*z_sinyal4GLTE*)	Denotes the strength of internet signal availability at the village level and serves as an instrumental variable in estimating digitalisation effects. Value 1 = if there is a 4G/LTE signal Value 0 = if 4G/LTE signal is not available
Control Variables/covariat	
Gender (*sex*)	Value 1 = if male Value 0 = if female
Age (*age*)	Age of household members expressed in years, calculated by rounding down to the nearest number.

Table 1.
Operational Definition of Research Variables (Continued)

Variable Name	Operational Definition
Control Variable/covariat	
Education (*educ*)	Highest level of education completed by household members
Working Experience (*experience*)	Value 1 = have prior work experience Value 0 = never been employed before
Classification of residential areas (*rural_urban*)	Value 1 = if urban Value 0 = if rural

Source: Author

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Regarding the digitalisation variable, while digitalisation is operationalised as a binary indicator, this approach inevitably entails a loss of information and conceptual shortcomings such as it conflates digitalisation with mere ICT use (where workplace digitalisation includes requirements, skills, work organisation, and outcomes, not just how much workers use media/the internet) and ignoring the skills and competence dimension (Audrin et al., 2024; Borle et al., 2021).

Instrumental Variable (IV)

This study employs an Instrumental Variable (IV) approach to estimate the causal effect of digitalisation on the economic conditions of the West Papuan population, as reflected in income levels. The instrumental variable (IV) method is used to address endogeneity issues arising from omitted variable bias, specifically unobserved factors that may simultaneously influence both digitalisation and income levels, such as individuals' digital technology adoption or adaptability and the presence of supporting infrastructure.

Furthermore, the method accounts for potential reverse causality, whereby an individual's income level may itself influence the degree of digitalisation (Chen et al., 2022). Individuals with higher incomes tend to have devices with adequate internet access (Cette et al., 2022). If estimation is forced under such conditions, the Ordinary Least Squares (OLS) procedure will generate biased results, leading to either an underestimation or overestimation of the actual parameter values.

 The dataset used in IV estimation is exclusively taken from the Sakernas August 2022. While the supporting data for the 4G/LTE signal availability instrument can only be constructed using the 2021 Podes, the 2018 Podes is no longer relevant for comparison with the Sakernas August 2021.

This study uses the IV 2SLS (*Two-Stage Least Square),* where the endogenous variable X_i (digitalisation) is approximated by the instrument variable Z_i (availability of 4G/LTE signal) which is correlated with X_i, but does not directly affect the outcome Y_i (total income), except through X_i (digitalisation). The stages and mathematical equations of model IV are as follows:

Stage 1: Regressing endogenous variables with instruments

$$x = \pi_0 + \pi_1 z + v$$

Stage 2: Regressing the outcome variable with the predicted value ($\hat{x}$) of the endogenous variable

$$y = \alpha_0 + \alpha_1 \hat{x} + u$$

Where the coefficient of $\hat{\alpha}_1$ is the *causal effect* estimation from the IV model. The consistency of the estimation results through the IV model will depend heavily on the validity of the instrument, which requires the instrument to meet two conditions

(Söderbom et al. (2014); Preston & Wright (2023)): 1). *Relevance: Cov(z,x)≠0* meaning that the instrument must have a strong correlation with the endogenous variable (can be measured by the value of *F-stat first stage* > 10). 2). *Exogeneity: Cov(z,u)=0* where the instrument affects the outcome variable y exclusively through its impact on the endogenous variable.

Propensity Score Matching (PSM)

The Propensity Score Matching (PSM) method constructs a comparison group (counterfactual) by matching the observable characteristics or covariate variables of the subjects in the treatment group with the control group (Khandker and Sahidur (2010); Getler et al.(2016)). This method has the advantage of reducing selection bias that arises due to non-randomness in determining treatment variables.

In the context of the pre-employment card program, participants choose to register voluntarily (self-assigned), so those who register tend to have certain characteristics that differentiate them from non-participants. This condition makes it difficult to isolate the true impact of the pre-employment card program. Therefore, the application of the PSM method is important to create a comparable comparison group. The implication is that the two groups formed will have similar characteristics, and any differences are due solely to participation in the pre-employment card program. Therefore, in the absence of the pre-employment card program, it is assumed that these two groups would have relatively similar outcome values (Ridha & Rumayya, 2024).

The dataset used in this PSM analysis is a pooled data combined from the Sakernas August 2021 and 2022. The treatment group consisted of young individuals (Generation Y/Millennials and Generation Z) who received the pre-employment card. A counterfactual group constructed based on covariate variables, which included sociodemographic factors such as gender, education level, work experience, and area of residence. The general equation in the PSM analysis method is written as follows:

$$Y_i = D_i Y_{1i} - (1 - D_i)Y_{0i}$$

Where $D_i \in \{0,1\}$ is *dummy* variable that has value of 1 if receiving the benefits of pre-employment card program and value of 0 if otherwise. Y_i is the outcome variable, namely the working status of the young population (*y_employment*). Y_{1i} is the expected outcome when the i-th individual is a recipient of a pre-employment card ($D_i = 1$). Y_{0i} is the expected outcome when individual i is included in the control group. The main analysis in the PSM method is the Average Treatment Effect on the Treated (ATT) value, which is as follows:

$$E\{Y_{1i}|D_i = 1\} - E\{Y_{0i}|D_i = 0\}$$

ATT can be interpreted as the difference between the estimated value of the potential outcomes of individuals who receive a pre-employment card, minus the potential outcomes of individuals who do not receive a pre-employment card.

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Results and Discussion

Analysis of population characteristics shows that the digitalisation adoption rate among the working-age population in West Papua reaches 25.74 percent. In addition, only 0.51 percent have taken part in the Pre-Employment Card program, leaving 99.49 percent with no prior engagement in its training activities. By gender distribution, men constitute the majority of the working-age population, accounting for 56.92 percent.

Table 2.
General characteristics of the working age population in West Papua

Characteristics		Percentage
Digitalisation	Yes	25.74
	No	74.26
Pre-Employment Card	Yes	0.51
	No	99.49
Gender	Male	56.92
	Female	43.08
Education	Lower	52.68
	Secondary	30.39
	Higher	16.93
Working Experience	Yes	32.69
	No	67.31
Classification of residential areas	Urban	28.86
	Rural	71.14
Age Classification	Gen X	32.74
	Gen Y	40.69
	Gen Z	26.57
Employment Status	Employed	63.63
	Unemployed	36.37
	mean	*min*	*max*
ln_income	14.41	0.6931	19.52

Source: Sakernas (2021-22) processed

From an educational perspective, the workforce in West Papua remains largely composed of individuals with limited formal schooling, accounting for 52.68 percent of the labor force, many of whom also possess minimal work experience. In terms of settlement patterns, 71.14 percent of the working-age population resides in rural areas. In terms of age demographics among the employed population, 63.63 percent of residents are engaged in work. The working-age population in West Papua is predominantly made up of Generation Y (born 1981–1996), which accounts for 40.69 percent. This is followed by Generation X (born 1965–1980) at 32.74 percent, and Generation Z (born 1997–2012) at 26.57 percent.

Figure 3 presents a bivariate choropleth map depicting the association between internet adoption and per capita GRDP, used here as a proxy for West Papua's economic performance in 2022. Districts and cities with higher indicator values appear in progressively darker shades. Sorong City is the only area positioned in the 3.3 quadrant, indicating both high per capita GRDP and high levels of digitalisation, with an internet adoption rate of 73.49 percent among individuals aged five and above and an annual per capita GRDP of 34.87 million.
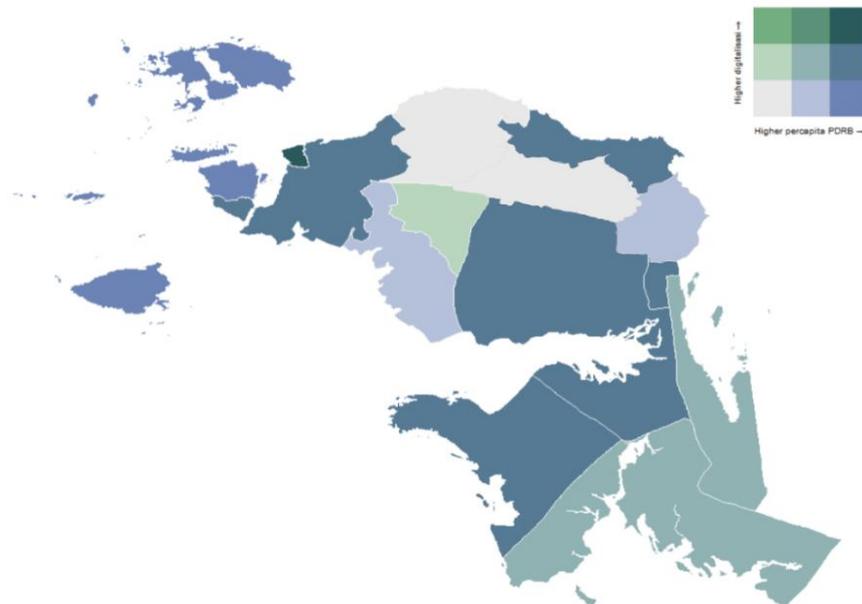
Source: BPS (2022) and BPS West Papua (2024a)

Figure 3.
Bivariate Choropleth Map **– Internet adoption and per capita GRDP between regions in West Papua, 2022**

Teluk Bintuni Regency ranks second (high per capita GRDP with moderate digitalisation) primarily because of its substantial per capita GRDP, reaching 286.88 million rupiah annually, driven largely by the oil and gas industry. Despite its strong economic performance, digital adoption remains moderate, reflected in an internet penetration rate of only 65.55 percent. In contrast, Pegunungan Arfak Regency exhibits the lowest level of development among all regions. It records the smallest per capita GRDP in West Papua, at just 4.5 million rupiah per year, and faces severe limitations in digital connectivity, with only 16.58 percent of residents aged five and above accessing the internet.

This gap highlights the urgency of implementing more targeted policy measures to ensure equitable expansion of digital infrastructure. Uniform internet accessibility across West Papua would not only broaden employment opportunities and enhance community productivity, but also serve as a fundamental prerequisite for fostering more inclusive and sustainable economic development.

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The Impact of Digitalisation on Income: Is it a shortcut to economic inclusion in West Papua?

To assess the effect of digitalisation on the income levels of the working population in West Papua, this study employs an Instrumental Variables (IV) approach, complemented by Ordinary Least Squares estimation to evaluate the robustness and reliability of the findings. The first-stage estimation utilises village-level 4G/LTE signal availability as the instrumental variable for digitalisation, followed by an instrument validity assessment. An F-statistic exceeding 10 in the first stage indicates that the instrument is sufficiently strong and appropriate for use.

Table 3
Estimation Results of the Impact of Digitalisation on Income

Outcome Var: Ln_income	Ordinary Least Square		Instrumental Variable (2SLS) (z = sinyal4GLTE)	
	Base	Full model	Base	Full model
digitalisation	0.7088***	0.4756***	1.2587***	0.9205**
	(0.02363)	(0.0266)	(0.12888)	(0.3710)
sex		0.2701***		0.2817***
		(0.0231)		(0.0252)
experience		0.094***		0.0736***
		(0.0220)		(0.0285)
education		0.0623***		0.0247
		(0.0046)		(0.0316)
rural_urban		0.2349***		0.1533**
		(0.0229)		(0.0718)
age		0.0481***		0.0461***
		(0.0053)		(0.0056)
age^2		-0.0005***		-0.00047***
		(0.00006)		(0.00007)
constanta	14.214***	12.699***	14.027***	12.743***
	(0.01378)	(0.11143)	(0.0454)	(0.1196)
R-square	0.1500	0.2323	0.0598	0.1918
First stage F-stat				36.75
Obs	5103	5103	5103	5103

*Robust standard errors in parentheses; * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
* The dataset used for estimation is from Sakernas August 2022

Table 3 reports the estimated effects of digitalisation on the earnings of the working population in West Papua. The findings align with expectations, showing that digitalisation yields a positive and statistically significant influence on income across both the OLS and IV specifications, with the magnitude of the effect differing between the baseline and expanded models. The corresponding regression equation for the IV estimation is presented below:

$$lnincome = 12.74 + 0.92\ digitalisation + 0.28\ sex + 0.07\ experience + 0.024\ education + 0.15\ rural\_urban + 0.05\ age - 0.0005\ age^2$$

Using the full OLS specification, digitalisation is estimated to raise the income of employed individuals by approximately $(e^{0,4756}-1)$ = 0,6089 x 100 = 60.89 percent relative to those who are not digitally engaged. In contrast, the full IV model, which applies 4G/LTE signal availability as an instrumental variable, suggests an even larger effect: digitalisation increases average income by an estimated 151.05 percent. Moreover, the first-stage F-statistic of 36.75 (>10) confirms that the instrument is strong, indicating that the IV estimates are statistically reliable.

The findings indicate that the OLS approach tends to yield downward-biased estimates of the causal effect of digitalisation. This bias arises from reverse causality, where income may influence digital adoption, and omitted variables that affect both digitalisation and earnings, such as digital infrastructure, market access, user motivation, and digital competencies. Consequently, the application of the IV method, which incorporates signal strength as a proxy for digital infrastructure availability, is appropriate as it mitigates these sources of bias and provides more credible estimates of digitalisation's true impact.

The estimation results further indicate that male workers, on average, earn 32.5 percent more than female workers, and individuals residing in urban areas receive higher incomes than those in rural locations. Prior work experience is also associated with a 7.6 per cent income increase compared with individuals who have no employment experience. Age is positively correlated with income; however, at later stages of the life cycle, captured through the non-linear age^2 term, factors such as career stagnation, impending retirement, or health limitations may contribute to declining earnings. An additional noteworthy finding concerns education: while educational attainment has a significant effect in the OLS specification, this relationship becomes statistically insignificant in the IV model. This discrepancy may reflect underlying endogeneity between education and income.

The pathway through which digitalisation influences societal well-being can be understood using the New Economic Geography (NEG) framework introduced by Paul Krugman (1998) and discussed in Durante & Benedetto (2022). Traditional NEG models emphasise how reductions in transport and transaction costs reinforce physical agglomeration, leading to spatial concentration of economic activity in core regions. In peripheral and geographically fragmented regions such as West Papua, however, physical agglomeration is structurally constrained by rugged terrain, dispersed settlements, and limited market density.

Workers in West Papua who utilise smartphones and the internet for job-related activities earn, on average, 2.5 times higher incomes than non-users. This finding supports the hypothesis that digital connectivity enhances individual productivity and market access. This study contributes to the literature by demonstrating that digitalisation partially substitutes for physical agglomeration, creating what may be

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described as virtual agglomeration. Consistent with recent extensions of NEG that incorporate digital connectivity (Durante & Benedetto, 2022; Du, 2025), digital technologies reduce effective distance not by relocating firms and workers, but by integrating remote economic actors into existing urban-centred production and consumption networks through online activities such as e-commerce, digital content creativity, online remote jobs, etc. In this sense, digital infrastructure weakens the core–periphery mechanism predicted by standard NEG models without fully eliminating spatial inequalities.

However, digital infrastructure in West Papua remains uneven, largely due to geographic isolation. According to the 2024 Village Potential data, more than half of all villages (54.53 percent) still lack a Base Transceiver Station (BTS), which is essential for transmitting and receiving signals that support internet connectivity. As a result, only 18.2 percent of villages across the province have access to strong mobile and internet coverage. This aligns with findings from the Indonesian Telecommunications Statistics (2024), which indicate that internet use among residents aged five and above in West Papua remains relatively low. Table 4 presents patterns of internet use for economic purposes, showing that utilisation is concentrated in accessing financial services (9.09 percent), followed by purchasing goods and services (6.89 percent), and selling goods and services (2.69 percent).

Table 4.

Percentage of population aged 5 years and over who use the internet according to the purpose of use

Type of activity	Purchase of goods and services	Sales of goods and services	Financial Facility	Work From Home (WFH)	Digital Content Creation
Percentage	6.89	2.69	9.09	2.02	3.58

Source: BPS (2024a)

Although the proportion of workers engaged in emerging digital activities, such as content creation, remains modest at 3.58 percent, this trend reflects the early stages of a digital transition with the potential to strengthen household economies, generate new income streams, and enhance economic inclusion in West Papua. Evidence from Maryen et al. (2024) underscores the importance of digital platforms, particularly for marketing and product sales, in improving the earnings of community enterprises, including MSMEs. Nonetheless, limited capacity in digital marketing, especially in managing social media, continues to pose a significant barrier for business actors in the region.

Worker Transition: *thriving or struggling after digitalisation?*

To examine more closely how digitalisation exposure influences worker welfare, this study incorporates an analysis of worker transitions. This method assesses shifts in well-being, specifically movements between more prosperous (thriving) and less

prosperous (struggling) worker groups, attributable to digitalisation. The results are presented using a Sankey diagram to illustrate changes in economic status more clearly.

The Sankey diagram illustrates the most prominent transition pattern, highlighted by the darker green flow. The visualisation indicates that more than one-third of workers classified as struggling in 2021 shifted to a thriving status in 2022 when exposed to digitalisation. A similar trend is observed among the thriving group, in which approximately one-third of individuals who were already prosperous in 2021 remained in that category in 2022, provided they continued to engage in digitalised work activities.

These findings are further supported by the results of Fisher's Exact Proportions Test, which reports a p-value of 0.000, indicating a statistically significant change in the share of workers who experienced improved economic conditions following digitalisation. The proportion of thriving workers is notably higher in 2022 compared with 2021. Although the number of workers who remain economically vulnerable is still substantial, the overall pattern underscores the strategic role of digitalisation as a catalyst for upward economic mobility among the workforce in West Papua.
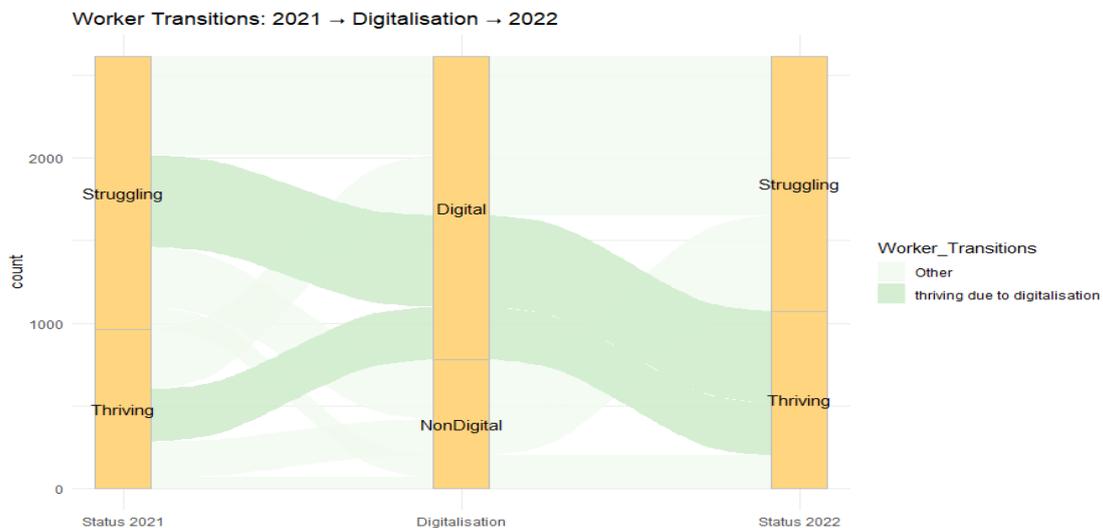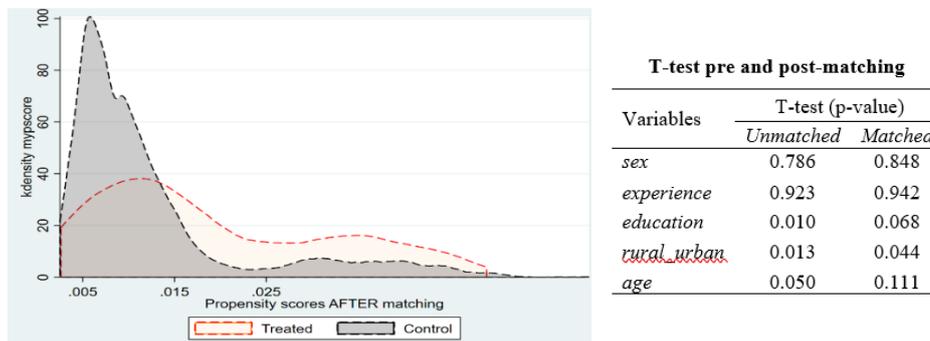

Source: Author (Processed)
Figure 4.
Sankey Diagram of Changes in Workers' Welfare Status in West Papua

Can the Pre-Employment Card Narrow the Employment Gap Facing Young People in West Papua?

The second aim of this study is to assess the effect of the Pre-Employment Card program on youth employment outcomes in West Papua using the Propensity Score Matching (PSM) approach. The matching procedure applies a combination of Nearest Neighbor and Radius Caliper Matching techniques. This method pairs individuals in the treatment and control groups based on the closest propensity scores, derived from

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comparable sociodemographic attributes, including gender, prior work experience, educational attainment, age, place of residence, and patterns of internet use.

Variables	T-test (p-value)	
	Unmatched	Matched
sex	0.786	0.848
experience	0.923	0.942
education	0.010	0.068
rural_urban	0.013	0.044
age	0.050	0.111

Source: Author (Processed)

Figure 5

Area of Common Support and T-test pre and post-matching

Figure 5 presents the kernel density distributions of estimated propensity scores for treated and control units after matching. The figure indicates that matching has succeeded in establishing a region of common support, particularly at lower propensity scores (ranging between 0.0025 and 0.035), where the distributions of treated and control observations substantially overlap. Nevertheless, the treated distribution remains systematically right-shifted relative to the control group, suggesting that treated units continue to exhibit a higher predicted probability of treatment even after matching. Additionally, the t-test assessing the differences between pre- and post-matching conditions indicates that matching effectively reduced systematic differences in observed characteristics between treated and control units, bringing the sample closer to balanced comparisons.

Table 5.

The Impact of the Pre-Employment Card on the Employment Status of Young People

Outcome Variable	Mean of Matched Treated	Mean of Matched Control	ATT	t-stat
Employment	0.6962	0.5738	0.1224	2.34**

Source: Sakernas 2021-2022 (Processed)

The PSM estimation shows an ATT value of 0.1224 with a t-statistic of 2.34, indicating that the Pre-Employment Card program results in a positive and statistically significant effect on employment outcomes in West Papua. These results suggest that young individuals (Generation Y/Millennials and Generation Z) who participate in the program have a 12.2 percentage-point higher probability of being employed than their non-participating counterparts.

The results of this study reinforce the findings of various previous studies, including Alatas et al. (2021), Presisi Indonesia (2021) and Tasmilah (2023) which

show that the pre-employment card program has a positive impact on employment opportunities, entrepreneurial growth, and increased community income. This program not only helps people find jobs but also serves as a catalyst in preparing the younger generation for an increasingly competitive and digitalized labor market.

Based on 2020 Sakernas data, more than 89 percent of Pre-Employment Card participants reported improved competency and skills after participating in training (Muhyiddin et al., 2022; Pignatti & Van Belle, 2021; Seskab RI, 2020). This achievement demonstrates that the program's training curriculum design aligns with market needs and can encourage increased competitiveness, productivity, and entrepreneurial spirit among the younger generation.

In 2022, participation in the Pre-Employment Card program in West Papua increased across successive batches, reaching a total of 86,103 beneficiaries. The largest concentrations of recipients were recorded in Manokwari Regency (8,167), Fakfak Regency (4,734), and Sorong Regency (4,438) (Kemenko Perekonomian, 2022). Although participation levels remain modest compared with other provinces, the program has played an important role in mitigating the economic consequences of the COVID-19 pandemic. By supporting labour-intensive sectors, the initiative contributes to regional economic recovery, while the incentives provided to trainees help to boost household consumption (Purbasari DP et al., 2022; BPK Papua Barat, 2021). Overall, the program performs a dual function: reinforcing household economic resilience and fostering a workforce better equipped to navigate the province's ongoing digital transformation.

Conclusion and Policy Recommendations

This study is grounded in the premise that the exposure of post-pandemic digitalisation and the expansion of online training initiatives, most notably the Pre-Employment Card program, serve as pivotal drivers of West Papua's economic recovery. The results indicate a strong positive association between digitalisation and individual income, with IV–2SLS estimates suggesting substantially higher earnings among digitally engaged workers, conditional on observable characteristics and instrument validity assumptions. Complementing this evidence, the PSM results indicate that the Pre-Employment Card program significantly enhances employment prospects for young people across the province. These findings provide context-specific evidence for West Papua rather than universal causal effects.

Overall, the findings suggest that sustaining exposure to digitalisation like in the post-pandemic context will enhance digital competitiveness, thereby providing a critical opportunity to redefine the development trajectory of West Papua. When access to digital infrastructure and skills training is expanded equitably, both contribute meaningfully to improving community welfare and fostering a more inclusive and resilient provincial economy. Based on these results, the following policy recommendations may be considered by the Government of West Papua:

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1. *Encouraging equitable distribution of technology and telecommunications infrastructure in West Papua*:
   - Prioritising the construction of base transceiver stations (BTS) and the expansion of fiber optic cables in areas with low connectivity such as in Pegunungan Arfak Regency, through a public-private partnership.
   - Providing affordable internet access in rural areas through community-based access points located in economic nodes (e.g. markets, cooperatives, or village enterprises).

2. *Promoting the expansion of digital financial inclusion across diverse economic sectors:*
   - The government can encourage digital financial inclusion through the use of digital payments such as Mobile Banking and QRIS.
   - Aligning digital financial literacy/understanding through campaigns, outreach, and community mentoring on the benefits and importance of digital payments for the West Papuan economy.
   - Facilitating access to financial services for business actors, through financing mechanisms such as peer-to-peer lending, OJK-licensed fintech lending, and ultra-micro financing that utilizes digitalisation in processing and verifying data.

3. *Continuing and expanding the benefits of the pre-employment card program:*
   - The government can reopen and expand the benefits of the pre-employment card program so that it reaches more people, especially young people.
   - The government should design and implement comprehensive, practical training modules focused on enhancing workforce competencies, with particular attention to empowering women. Additionally, targeted training in social media management and digital marketing is essential for workers who have begun leveraging digital platforms to boost productivity but continue to encounter technical and managerial challenges in promoting and commercializing their products.

This study acknowledges several limitations that may inform future research. First, the use of the August 2021 and 2022 Sakernas datasets captures only the initial phase of West Papua's post-pandemic economic recovery. Consequently, updated analyses using more recent datasets, particularly those collected after the provincial restructuring, are essential to reflect current economic conditions and to more precisely assess the influence of digitalisation and the effectiveness of the Pre-Employment Card program within West Papua's evolving regional landscape. Second, future studies should address potential endogeneity issues present in the education and income variables to enhance the robustness and credibility of the analytical results.

Ethics Statement

This research involved secondary, anonymised microdata from Susenas and Podes, provided by Statistics Indonesia (BPS). Access to the data is restricted and can be obtained through a formal application to BPS. Since the data does not contain any personally identifiable information, all analyses were conducted in compliance with the data usage regulations established by BPS.

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