

Accelerating Job Search: The Influence of Internet Penetration on Reducing Youth Unemployment Duration in Indonesia

Adrian Nalendra Perwira

Department of Economics, Faculty of Economics and Business, Universitas Indonesia, Depok, Indonesia

Corresponding author: adrian.nalendra@ui.ac.id

I Dewa Gede Karma Wisana

Department of Economics, Faculty of Economics and Business, Universitas Indonesia, Depok, Indonesia

Lembaga Demografi, Faculty of Economics and Business, Universitas Indonesia, Depok, Indonesia

Abstract

We investigate the impact of internet penetration on the duration of youth unemployment in Indonesia from 2008 to 2018. Using a municipality-level panel dataset constructed from Sakernas, Susenas, and Podes, the analysis applies fixed-effects and instrumental variable models to address potential endogeneity. Results indicate that higher internet penetration is associated with shorter durations of youth unemployment. A 1-percentage-point increase in municipal internet penetration reduces average unemployment duration by 0.09 to 0.51 months, depending on the model used. The study also finds a modest but significant negative relationship between internet penetration and unemployment rates. Robustness checks using lagged controls and lead-lag specifications confirm the direction and strength of these effects. These findings confirm the role of digital infrastructure in reducing job search frictions and improving youth labor market efficiency. The development of the Indonesian Broadband Plan may be critical for enhancing youth employment outcomes.

Keywords: youth unemployment duration, internet penetration, digital infrastructure, endogeneity.

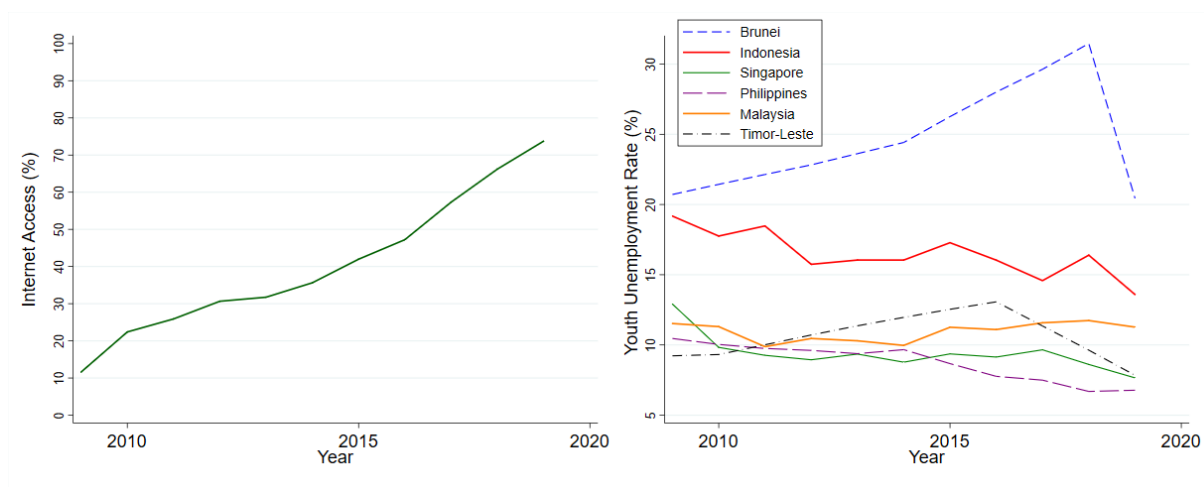
1. Introduction

The expansion of broadband internet has transformed labor markets, facilitating faster job matching, remote work, and access to skill development platforms. By reducing search costs and enabling real-time labor market information, internet access can improve matching efficiency between employers and job seekers (Autor, 2001). The problem is particularly relevant in developing economies because employment accessibility issues persist across different geographical areas.

In Indonesia, the urgency of addressing youth unemployment is heightened by the country's demographic dividend. A large share of the population is of working age, and effective labor market policies are essential to convert this into productive employment and higher per capita output (Hayes & Setyonaluri, 2015). In preparation for the significant cohort entering the workforce over the next 25 years, labor market policies should prioritize flexibility in terms of employment conditions, minimum wages, and working hours (Bloom et al., 2003).

Youth unemployment in Indonesia remains a pressing issue. While international institutions such as the World Bank and the International Labour Organization (ILO) define youth as individuals aged 15 to 24, Indonesian law extends this range to 16–30, categorized as "*pemuda*." According to Statistics Indonesia (BPS), youth unemployment includes individuals in this age group who are actively seeking work, preparing to start a business, or awaiting job placement. In 2019, Indonesia's youth unemployment rate stood at 13.6%, the second-highest in Southeast Asia, despite a gradual decline over the past decade (Figure 1, right panel).

Figure 1. Household internet access and youth unemployment rates:
Indonesia and selected Southeast Asian countries (2009–2019)



Source: Statistics Indonesia (2024) and World Bank (2024)

High youth unemployment not only limits economic potential but is also linked to increased risks of drug use, criminal activity, and vulnerability to extremist ideologies (Fougère et al., 2009; Raphael & Winter-Ebner, 2001). Prolonged unemployment can lead to social instability, irregular migration, and long-term economic exclusion (Hilker & Fraser, 2009). If left unresolved, short-term unemployment risks evolve into long-term unemployment, typically after 12 months, which significantly affects individual well-being and broader socioeconomic outcomes (Başol et al., 2023).

At the same time, internet access in Indonesia expanded rapidly, with household connectivity rising from 11.6% in 2009 to 73.8% in 2019 (Figure 1, left panel). Despite these digital advances, persistently high youth unemployment indicates that internet access alone is insufficient to improve labor market outcomes, especially without supporting infrastructure, skills, and job-matching systems.

Research on internet access and labor outcomes mainly focuses on developed economies, leaving a gap in understanding the impact of digital infrastructure on youth employment in developing nations. This study aims to fill that gap by

examining how internet penetration influences youth unemployment in Indonesia. It demonstrates that internet access affects labor outcomes by changing job search duration, thereby adding to the literature on this issue in developing regions. It also uses fixed-effects and instrumental variable (IV) strategies to tackle endogeneity, leveraging terrain slope variations as an exogenous factor for internet rollout. Furthermore, the study analyzes unemployment duration and rates to investigate how internet access improves search efficiency and overall labor market absorption at the municipal level. Results show that municipalities with higher internet penetration experience significantly shorter youth unemployment durations. IV estimates suggest that a 1-percentage-point increase in internet access can reduce unemployment duration by approximately 0.51 months, although weak identification diagnostics require cautious interpretation. In contrast, fixed-effects models yield robust estimates with coefficients between -0.090 and -0.135 . Additionally, internet penetration is linked to a slight but significant decrease in municipal unemployment rates, indicating broader implications for labor market absorption. This research highlights the crucial role of digital infrastructure in enhancing job matching and reducing search frictions.

This paper is structured as follows: Section 2 reviews relevant literature and identifies key gaps. Section 3 presents the theoretical framework. Section 4 describes the empirical strategy, including model specifications. Section 5 details data sources and variable construction. Section 6 reports the main results, including robustness checks. Section 7 concludes with a summary of findings, policy implications, and limitations.

2. Literature Review

2.1 Previous Research on Youth Unemployment

Structural mismatches and transitional frictions are key drivers of youth unemployment across diverse economies. Employment outcomes are influenced mainly by education, work experience, and macroeconomic stability (Brück-Klingberg et al., 2011; Flek et al., 2015). In transition economies, overeducation and urban labor market congestion further prolong unemployment (Boršič & Kavkler, 2009; Petreski et al., 2017).

Digital infrastructure is increasingly recognized as a key enabler for improving youth employment, particularly in underserved areas. Studies in Sub-Saharan Africa (Metu et al. 2020) and Europe (Başol et al. 2023) find that expanded mobile and broadband access enhances employment by improving connectivity, enabling skill development, and fostering labor market participation. These findings support broader evidence on the role of information and communication technology (ICT) in addressing youth unemployment.

In Indonesia, youth unemployment reflects similar individual and structural dynamics. While higher education and work experience increase employability, urban youth face greater challenges despite better infrastructure (Sitompul & Athoillah, 2023). Macroeconomic factors, such as GDP growth and foreign direct investment, also influence youth employment (Hasan & Sasana, 2020). However, a persistent mismatch between educational attainment and labor market demands results in longer unemployment duration and wage penalties for overeducated youth (Friska & Damayanti, 2021; Pasay & Indrayanti, 2012; Sukanti & Sulistyaningrum, 2022). Similar patterns are reported across Southeast Asia, where structural mismatches contribute to stagnant youth employment outcomes (Tangtipongkul & Wangmo, 2018).

ICT presents opportunities to address these challenges. In Indonesia, broadband access significantly reduces unemployment by improving information flow and enabling economic participation (Salsabila & Oktora, 2022). Integrating digital tools into training, enhancing job-matching systems, and addressing skill mismatches can further improve labor market efficiency. Evidence suggests that strengthening ICT infrastructure and policy can play a critical role in reducing youth unemployment.

2.2. Internet Expansion on Labor Market Outcome

Home internet access is increasingly shaping labor market dynamics, especially in developing countries with uneven digital infrastructure. This study contributes to the literature by examining the relationship between household internet connectivity, job search efficiency, and youth unemployment duration in a middle-income context. While Internet Job Search (IJS) has been studied, few studies treat home internet access as a treatment variable with direct labor market implications.

Kuhn and Skuterud (2004) found limited evidence that online job seekers experienced shorter unemployment spells after controlling for observable factors. However, Kuhn and Mansour (2014), using updated data and improved metrics, showed IJS reduced unemployment duration by over 25%, attributing this to technological advances and enhanced job platforms. The effects were more pronounced among older individuals and statistically insignificant for those aged 23–29, highlighting demographic differences in the use of internet resources.

Several studies employ causal identification strategies to assess broadband's impact. In Turkey, Atasoy (2013) finds broadband expansion increases employment via productivity gains and better job matching. In Germany, Gürtzgen et al. (2021) and Denzer et al. (2021) report significant reductions in unemployment duration,

particularly among men and proactive job seekers. Salsabila and Oktora (2022) find similar effects in Indonesia, though with regional disparities in access.

Yet, findings remain mixed. Jin et al. (2023) report no significant effect on employment rates in China but note improvements in job quality for unskilled workers. Studies from Germany (Czernich, 2014; Fabritz, 2013) find minimal effects, while Dettling (2017) shows that U.S. broadband access increases labor force participation only among married women with children. Such variation reflects differences in definitions, methods, and population characteristics.

Overall, internet access affects labor markets unevenly. While many studies show positive impacts through reduced search frictions, others report limited or no effects. These inconsistencies arise from methodological variation and structural heterogeneity in digital literacy, education, and institutional support. Evidence suggests that broadband yields more substantial effects where complementary infrastructure and skills are in place (Atasoy, 2013; Dettling, 2017; Jin et al., 2023; Stockinger, 2019).

Based on these insights, this study hypothesizes that municipalities with higher home internet access experience shorter durations of youth unemployment. The next section outlines the theoretical framework and empirical strategy, integrating job search theory and econometric methods to explore the mechanisms linking internet access and labor market outcomes in the Indonesian context.

3. Theoretical Framework

The relationship between internet penetration and labor market outcomes has been widely examined through job search and matching theories. This study adopts the Diamond–Mortensen–Pissarides (DMP) framework (Pissarides, 2000) to explore how improvements in matching technology, proxied by internet access, influence youth unemployment duration. Internet penetration is conceptualized as a

technological advancement that enhances search costs and frictions, thereby increasing matching efficiency.

This study focuses on the broader labor market effects of internet access rather than narrow IJS behavior (e.g., Kuhn & Mansour, 2014; Choi, 2023). Following Autor (2001) and Gürtzgen et al. (2021), internet access is treated as an exogenous factor influencing matching outcomes. The measure, constructed from Susenas data, captures the percentage of households within each municipality accessing the internet in the past three months, allowing for temporal and geographic variation across Indonesia.

To translate these theoretical insights into empirical analysis, this section outlines the framework and corresponding econometric specifications employed to investigate the relationship between internet access and unemployment duration in Indonesia.

The process by which employees and enterprises with vacancies meet is frequently described using a meeting function m , which is a function of the measure of unemployed workers (u_t) in the market and the measure of vacancies (v_t). Workers aim to optimize their incomes' net present value and engage in random job searches when unemployed. Companies optimize revenues by employing workers but must allocate resources to recruit them. This search procedure delays immediate hiring and results in high levels of unemployment (u_t) and vacancies (v_t). The matching function is represented as $m(u, v) = \alpha u^\beta v^\gamma$, where α represents matching efficiency and β and γ represent unemployment elasticity with respect to match. α , β , and γ are positive values, and when $\beta + \gamma = 1$, it results in a constant return to scale function. This function generates firm–worker matches by using job postings and employment searchers as its input.

An increase in meeting frequency for specific u and v indicates better meeting technology. Thus, the value α represents the meeting technique. In our framework,

internet growth is reflected in α . Job boards enable keyword searches and provide more information than traditional print ads. Gürtzgen et al. (2021) state that online job offers are more current than print ones due to fewer time delays. The initial influence of matching technology would be seen in parameter α if internet coverage improved. A higher α value boosts the matching rate, resulting in more hires from the same pool, which enhances job seekers' re-employment and reduces unemployment. Job applicants expect quicker placements, which broaden their options and increase potential wages. Enhanced matching technology shortens vacancy durations, while free entry encourages more job postings, creating uncertainty in the vacancy rate (Bhuller et al., 2020).

Researchers apply the DMP job search model under steady-state conditions to analyze the relationship between the effects of internet penetration using the traditional theory of unemployment and vacancies. This model elucidates that the discrepancy between an individual's internet coverage and their present occupation is a consequence of the process of aligning individuals with corporations. The DMP theory asserts that the likelihood of leaving unemployment, often known as the hazard rate (ϕ_j), is determined by two factors.

First, Gürtzgen et al. (2021) stated that unemployed individuals can influence the number of job offers they receive (λ_j) by adjusting the amount of effort they put into searching for employment. This level is selected with consideration for search expenses. The internet decreases search costs, which in turn increases search effort and improves matching efficiency α . Undoubtedly, there is substantiating evidence supporting this claim. Job boards enable the distribution of information at a significantly reduced expense compared to print advertisements. Additionally, the expenses associated with submitting an application online may be significantly lower compared to the fees incurred when sending a physical letter. The aforementioned rationale is equally applicable to employers seeking potential candidates (Autor, 2001).

Second, the job offer arrival rate (λ_j) quantifies the impact that originates from the labor market. One of the variables employed in this study to indicate the labor market component is the categorization of the residence region as either urban or rural. Ismail and Kollamparambil (2015) in South Africa suggest that job seekers residing in rural areas have a lower hazard rate compared to those living in urban areas. Put simply, job seekers in rural areas have a lower likelihood of securing employment compared to those in urban areas. One factor contributing to this is the comparatively low labor market activity and limited employment opportunities in rural areas, which can be attributed to a less diversified economy. The acceptance probability of a job ($1 - F_j(w^*)$) is determined by job searchers and is contingent upon their reservation wage. Individuals seeking employment who have a greater minimum salary need (w^*), but receiving job offers at the same rate (λ_j), are generally less inclined to accept a job offer. Put simply, as the likelihood of accepting a job ($1 - F_j(w^*)$) decreases, the hazard rate grows.

Therefore, whether the hazard rate (ϕ_j) is greater or smaller depends on the wages offered and the arrival rate of job offers. If the arrival rate of job offers increases, the job seeker's reservation wage increases because they have more options. The rise in the rate at which job offers are received, particularly with the advent of the internet, encourages individuals to be more discerning regarding the quality of the offers they consider. As a result, this increases the minimum pay individuals are willing to accept before accepting a job offer, known as the reservation wage.

The average unemployment duration $\equiv T_u$ is shown as:

$$T_u = \frac{1}{\phi_j} = \frac{1}{\lambda_j[1 - F_j(w^*)]} \quad (1)$$

The effect of an increase in the job arrival rate (λ_j) on the unemployment duration, T_u is ambiguous and depends on the extent to which λ_j affects the reservation wage

(w^*). If w^* remains constant, then λ_j will decrease T_u . However, if w^* increases significantly in response to a higher λ_j , the effect on T_u could be positive.

This theoretical ambiguity motivates the empirical analysis that follows. The next section outlines the identification strategy and econometric framework used to estimate the relationship between internet penetration and youth unemployment duration.

4. Empirical Method

One significant issue is the non-random selection into internet use, correlated with job search behavior. Individuals with home internet access likely differ in employment prospects due to unobserved factors like productivity. Furthermore, the impact of internet use on job search duration may vary, with those having internet access being the most likely to opt into the treatment group, raising endogeneity concerns. We address this using an instrumental variables (IV) approach, leveraging geographic variation in internet infrastructure as an instrument. Specifically, differences in broadband rollout, driven by supply constraints, create exogenous variation in access (Denzer et al., 2021). Unlike dial-up, broadband required substantial investment from internet service providers (ISPs), leading to uneven diffusion across regions (Dettling, 2017).

The model is expressed as:

Second Stage Regression

$$avgdur_{it} = \beta_{0it} + \beta_1 Internet_{it} + \beta_2 x'_{it} + \gamma_i + \theta_t + \epsilon_{it} \quad (2)$$

Where $avgdur_{itm}$ represents the average duration of youth unemployment in municipality i and year t . $Internet_{it}$ represents the percentage of households within a municipality that have internet access, x'_{it} is a vector of time-varying district-level

control variables, γ_i represents the municipality-specific fixed-effects, while θ_t are the year fixed-effects.

The model is expressed as:

First Stage Regression

$$Internet_{it} = \beta_{0it} + \beta_1 Z_{it} + \beta_2 x'_{it} + \gamma_i + \theta_t + \mu_{it} \quad (3)$$

Where Z_{it} represents the average terrain slope interacted with year fixed-effects. As in the first model, x'_{it} is a vector of time-varying district-level control variables, γ_i represents the municipality-specific fixed-effects, while θ_t are the year fixed-effects.

The theoretical model posits that increased internet penetration enhances the job arrival rate (λ_j), which reduces the duration of unemployment (T_u). The empirical model tests this hypothesis by estimating the coefficient β_1 in the second stage regression. A significant negative β_1 coefficient indicates that higher internet penetration is associated with shorter unemployment durations, supporting the theoretical expectation that increased internet access improves the efficiency of job matching, thereby reducing the time individuals spend unemployed. This outcome would validate the hypothesis that enhanced internet access facilitates quicker job matches and reduces the average duration of unemployment. Conversely, a significant positive β_1 coefficient would indicate that higher internet penetration is associated with longer unemployment durations. This could imply that while internet access increases the availability of job offers, it might also encourage job seekers to be more selective, leading to longer periods of job seeking as they hold out for better opportunities. Such a result would indicate that the benefit of more frequent job offers is offset by the increased selectivity of job seekers, resulting in longer unemployment durations (Gürtzgen et al., 2021).

To empirically test the theoretical predictions and econometric specifications described above, reliable data at the municipal level are required. The following

section describes how the dataset was constructed from various nationally representative surveys and clearly defines the key dependent, explanatory, instrumental, and control variables employed in the analysis.

5. Data and Variables

This study uses a panel dataset of 427 Indonesian municipalities over four waves (2008, 2011, 2014, and 2018), yielding 1,708 municipality-year observations, to analyze the effect of internet penetration on youth unemployment duration. The data integrates three nationally representative surveys: the National Labor Force Survey (Sakernas), the National Socioeconomic Survey (Susenas), and the Village Census (Podes). Youth unemployment duration and demographics were aggregated from Sakernas, while Podes provided control variables on local infrastructure and economic conditions. Internet penetration, the main explanatory variable, is derived from Susenas, defined as the share of households with internet access in the past three months. The datasets were merged using consistent municipality identifiers to create a longitudinal panel.

5.1 Dependent Variables

The dependent variable in this study is the average of job search among youth, measured in months at the municipality level. Following BPS (Sakernas) guidelines, job search duration is defined as the time between initiating a job search and securing the most recent main job. Youth unemployment refers to individuals aged 16–30, in line with the definitions of Law No. 40/2009 and Statistics Indonesia. This includes those actively seeking work, preparing to start a business, or awaiting a job offer but not yet employed within the past month, capturing diverse stages of youth job search behavior.

5.2 Explanatory Variables

This study sees internet penetration as a factor that boosts job-matching efficiency by lowering search costs and increasing job procurement rates. It measures internet penetration as the percentage of households in a municipality that accessed the internet in the last three months, irrespective of device type. Following Denzer et al. (2021), home internet access serves as a broad proxy for digital availability. This approach captures the overall impact of internet access on employment, treats job search methods as intermediate mechanisms (i.e., Internet Job Search or IJS), and mitigates recall bias from self-reported search behavior. The consistent use of Susenas data before and after internet expansion allows assessing the total effect of internet access on youth unemployment duration, beyond specific search platforms. By emphasizing internet penetration alongside traditional job search methods, this study enhances understanding of how internet accessibility influences employment dynamics.

5.3 Instrumental Variable

This study employs an instrumental variables (IV) approach to address endogeneity, using the weighted average of terrain slope, derived from village census (Podes) data, as the instrument, interacted with year fixed-effects. Village slopes are categorized as gentle, medium, and steep, aggregated at the municipal level. Steeper terrain increases the cost and complexity of internet infrastructure, potentially reducing internet penetration (Kolko, 2012). However, slope is unlikely to directly affect job search duration, meeting the exclusion restriction.

Following Rezki (2023), who advocates interacting time-invariant instruments with dynamic components, we interact the terrain slope with year fixed-effects to account for temporal variation and uneven survey intervals. This approach isolates exogenous variation in internet access attributable to geographic constraints,

providing a credible identification strategy. The following section presents the first-stage regression results, which validate the strength of the best instrument.

5.4 Control Variables

To account for heterogeneity across municipalities, the analysis includes controls capturing economic, demographic, technological, and geographic characteristics. Economic variables comprise the log of GRDP, real daily wages (inflation-adjusted), and provincial minimum wages, all key indicators of local economic conditions and labor market incentives. Demographic controls include the share of households with higher education, female labor force participation, population density, and total population, reflecting variations in human capital, gender dynamics, and labor market scale.

Technological infrastructure is proxied by the share of villages with strong internet signals, e-kiosks, and fixed-line internet, complementing the primary internet penetration variable. Additional controls include the presence of job training programs and the share of villages oriented toward trade or services, capturing differences in skill development opportunities and local economic structure.

Table 1 shows that the average duration of youth unemployment has a mean duration of approximately 13.05 months, with a standard deviation of 7.51 months.

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Average duration of youth unemployment (in months)	1708	13.05	7.51	1.00	64.03
Percentage of households with internet access	1708	22.90	16.29	0.00	72.53
Logarithm of gross regional domestic product	1708	15.71	1.28	12.17	19.87
Provincial minimum wage (in Indonesian Rupiah)	1708	1318415	636217	500000	3648036
Population density (people per km ²)	1708	1168.49	2541.70	0.54	20885.11
Logarithm of total population in the municipality	1708	12.74	0.98	9.61	15.35
Real daily wage (in Indonesian Rupiah)	1708	33050.55	19820.94	730	130045

Percentage of households with higher education	1708	56.09	16.14	9.09	94.32
Percentage of male youth in the population	1708	50.14	1.50	44.53	55.96
Rate of formal employment	1708	35.26	15.55	0.37	81.21
Female labor force participation rate	1708	53.19	10.66	18.66	98.22
Percentage of villages in valley areas	1708	4.25	8.52	0.00	89.87
Percentage of villages with hospitality services	1708	13.87	17.07	0.00	100.00
Percentage of villages with traditional markets	1708	27.52	17.65	0.00	100.00
Percentage of villages with stores	1708	92.36	13.35	5.60	100.00
Percentage of villages with food and beverage services	1708	69.23	29.45	0.00	100.00
Percentage of villages dominated by services sector	1708	8.42	15.17	0.00	88.46
Percentage of villages dominated by trade sector	1708	7.78	13.02	0.00	83.33
Percentage of villages with strong internet signal	1708	71.19	23.28	0.58	100.00
Percentage of villages with e-kiosks	1708	25.37	28.34	0.00	100.00
Percentage of villages with fixed-line internet	1708	32.06	33.83	0.00	100.00
Percentage of villages offering job training programs	1708	23.77	20.05	0.00	100.00
Weighted average of terrain slope across villages in the municipality	1708	103.01	83.05	1	642.75
Year dummy: 2008	1708	0.25	0.43	0.00	1.00
Year dummy: 2011	1708	0.25	0.43	0.00	1.00
Year dummy: 2014	1708	0.25	0.43	0.00	1.00
Year dummy: 2018	1708	0.25	0.43	0.00	1.00

This indicates a wide variation in unemployment durations, with the shortest term being 1 month and the longest being 64.03 months. The high maximum value suggests the presence of some extreme cases where youths experienced prolonged unemployment.

This study integrates key variables to construct a comprehensive framework for analyzing the duration of youth unemployment. Table 1 presents descriptive statistics, highlighting their relevance. The primary explanatory variable, i.e., household internet access, averages 22.90% across municipalities (SD = 16.29%), ranging from no access (0%) to 72.53%, indicating a substantial digital divide.

Additional contextual variables include job training programs, present in 23.77% of villages on average, and sectoral composition, which captures local economic structures. The provincial minimum wage averages IDR 1,318,415, reflecting notable regional variation in labor market conditions. While strong internet signals are present in 71.19% of villages on average, coverage varies widely. Similarly, only 25.73% of villages have e-kiosks, highlighting disparities in digital infrastructure. These variations underscore the importance of controlling for local context to ensure robust estimates.

6. Results

This section aims to illustrate the impact of internet penetration on the length of job searches for various model specifications. To determine the initial association between internet access and youth unemployment duration, we begin with the baseline regression models before moving into the deeper inferential analysis.

6.1. Baseline Regression Analysis

Table 2 provides baseline regression for the relationship between internet access and youth unemployment duration. Column (1) presents a basic OLS regression without control variables or fixed effects. The coefficient of internet penetration is -0.190 and highly significant, indicating that increased internet access is strongly associated with shorter youth unemployment durations.

Table 2. Baseline regression estimation result

Variable	(1)	(2)	(3)	(4)	(5)	(6)
Household internet penetration	-0.190*** (0.011)	-0.069*** (0.013)	-0.089*** (0.021)	-0.096*** (0.028)	-0.026 (0.029)	-0.090*** (0.034)
Control	No	No	Yes	Yes	Yes	Yes
Municipality FE	No	No	No	No	Yes	Yes
Time FE	No	Yes	No	Yes	No	Yes

Constant	17.414*** (0.303)	19.294*** (0.317)	44.960*** (7.143)	32.087*** (6.719)	48.492** (23.020)	50.780** (24.813)
Obs	1708	1708	1708	1708	1708	1708
Number of municipalities	427	427	427	427	427	427
R-squared	0.171	0.560	0.460	0.560	0.549	0.573

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable in this estimation is the average duration of youth unemployment. The years included in the regressions are 2008, 2011, 2014, and 2018. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Column (2) introduces time fixed effects, while Columns (3) and (4) sequentially add control variables and both time fixed effects and controls. In Column (4), the coefficient on internet penetration is -0.096 and statistically significant at the 1% level. This estimate remains consistent in sign and magnitude across specifications, indicating that the association persists after accounting for both temporal factors and observed covariates.

When municipality fixed effects are included (Column 5), the coefficient on internet penetration decreases in magnitude and becomes statistically insignificant. In the fully specified model (Column 6), which incorporates both municipality and time fixed effects, the coefficient is -0.090 and remains statistically significant at the 1% level. This pattern suggests the association between internet access and unemployment duration is robust to including regional and time-specific controls.

These patterns are consistent with the job-matching framework, where improved internet access is expected to raise the job arrival rate by reducing search frictions. The following section addresses potential endogeneity concerns by introducing an instrumental variable approach.

6.2. Panel Fixed-Effect IV Regression: Household Internet Penetration and Youth Unemployment Duration

Table 3¹ presents the two-stage least squares (2SLS) regression results investigating the effect of household internet access on the duration of youth unemployment. The excluded instruments, average terrain slope interacted with year dummies (2011, 2014, and 2018), leverage geographical variations in internet infrastructure development over time.

Table 3. Two-stage least squares (2SLS) estimation of the impact of internet penetration on youth unemployment duration

Variable	Youth unemployment duration	Youth unemployment duration
Household internet penetration	-0.291** (0.127)	-0.506** (0.204)
Control	No	Yes
Municipality FE	Yes	Yes
Time FE	Yes	Yes
Obs	1708	1708
Number of municipalities	427	427
First Stage		
Average Terrain Slope X Year 2011	-0.030***	-0.019***
Average Terrain Slope X Year 2014	-0.027***	-0.017***
Average Terrain Slope X Year 2018	-0.017***	-0.010***
<i>F</i>	9.781	7.099
Stock-Yogo critical value	9.080	9.080

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable is the average duration of youth unemployment. The interaction terms of average terrain slope and year dummies for 2011, 2014, and 2018 are used as excluded instruments. Both models account for municipality and year fixed effects, with 2008 as the reference year for the year dummies. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

This approach relies on the exogenous variation in internet penetration, thereby reducing concerns about reverse causality or omitted variable bias. The analysis incorporates municipality and year fixed effects, with 2008 as the base year,

¹ The table with full control variables is shown in the Appendix.

along with additional control variables covering economic, demographic, and technological factors.

The results from the IV regression reveal a significant negative relationship between household internet penetration and youth unemployment duration. Specifically, the coefficient for internet penetration in the second-stage regression is -0.506 ($p < 0.05$). This indicates that a 1-percentage-point increase in internet penetration reduces youth unemployment by approximately 0.5 months, holding constant fixed effects and control variables. This finding is consistent with the job-matching framework, particularly the DMP model, where internet penetration is hypothesized to increase the job offer arrival rate (λ_j) and thereby reduce the expected duration of unemployment (T_u).

To evaluate the broader effects of internet penetration on labor market outcomes, we performed an additional analysis utilizing the same model and control variables, substituting youth unemployment duration with unemployment rates as the dependent variable. Table 4 presents the results of the supplementary IV analysis using the municipal unemployment rate as the dependent variable. In the specification without controls, the coefficient for internet penetration is -0.167 ($p < 0.01$). With the inclusion of controls, the coefficient decreases in magnitude to -0.144 and is significant at the 10% level. These results indicate that internet access negatively affects unemployment rates across Indonesian municipalities.

Table 4. Two-state least squares (2SLS) estimation of the impact of internet penetration on unemployment rate

Variable	Unemployment rate	Unemployment rate
Household internet penetration	-0.167^{***} (0.050)	-0.144^* (0.079)
Control	No	Yes
Municipality FE	Yes	Yes
Time FE	Yes	Yes
Obs	1708	1708

Number of municipalities	427	427
First Stage		
Average Terrain Slope X Year 2011	-0.030***	-0.019***
Average Terrain Slope X Year 2014	-0.027***	-0.017***
Average Terrain Slope X Year 2018	-0.017***	-0.010***
<i>F</i>	9.781	7.099
Stock-Yogo critical value	9.080	9.080

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable is the municipality's unemployment rate. The interaction terms of average terrain slope and year dummies for 2011, 2014, and 2018 are used as excluded instruments. Both models account for municipality and year fixed-effects, with 2008 as the reference year for the year dummies. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The first-stage regression results validate the relevance of the instruments, with statistically significant coefficients for the interaction terms between average terrain slope and year dummies (-0.019 , -0.017 , and -0.010 ; $p < 0.01$ for all). These findings confirm that steeper terrain consistently impedes the rollout of internet infrastructure, reducing penetration over time. This relationship aligns with prior evidence, such as Kolko (2012), who found a negative correlation (-0.14 , $p < 0.01$) between broadband availability and terrain slope.

Table 5 presents the post-estimation diagnostics used to assess the robustness of the IV approach. The under-identification test, as measured by the Kleibergen-Paap rk LM statistic (28.58, $p < 0.001$), rejects the null hypothesis of under-identification, confirming that the instrument is relevant. However, the Kleibergen-Paap Wald F-statistic (7.099) falls below the Stock-Yogo critical value of 9.080, indicating weak instrument concerns at the 10% maximal IV relative bias threshold.

The first-stage F-statistic exceeds the threshold without controls but declines when controls are included, reflecting a trade-off between model completeness and instrument strength. While the instruments pass the under-identification test and perform adequately in simpler models, weak identification remains a concern. Thus, IV estimates should be interpreted with caution. Fixed-effects models are employed to mitigate bias, given the limitations posed by weak instruments. In summary, while the instruments pass the under-identification test, demonstrate

significant relationships in the first stage, and perform adequately in simpler models, the weak identification diagnostics suggest limitations in their robustness. This underscores the challenges of relying on potentially weak instruments and supports the decision to prioritize fixed-effects models for a more reliable basis for inference.

Table 5. Summary of post-estimation diagnostics for instrument relevance and strength

Test Statistic	Value	p-value	Interpretation
Kleibergen-Paap rk LM Statistic (Under-identification Test)	28.58	<0.001	Rejects the null hypothesis of under-identification, confirming the instrument is relevant.
Kleibergen-Paap rk Wald F Statistic (Weak Identification Test)	7.099	-	Falls below critical threshold, suggesting potential weak instrument concerns.
Stock-Yogo Critical Value (10% Maximal IV Relative Bias)	9.08	-	Critical value threshold for weak instrument test at 10% bias level.

Note: The table presents key post-estimation diagnostics for the IV regression models examining the relationship between internet penetration and labor market outcomes.

6.3. Panel Fixed-Effect Regression Analysis: Household Internet Penetration and Youth Unemployment Duration

Given concerns about instrument strength, the analysis relies on fixed-effects panel models as a more robust framework for inferences. This approach controls for unobserved time-invariant heterogeneity, enhancing the credibility of the estimated relationship between internet penetration and youth unemployment duration. Table 6² presents fixed-effects estimates for two outcomes, i.e., youth unemployment duration and municipal unemployment rate, using both baseline and lagged control specifications to test robustness.

In the baseline fixed-effects model for youth unemployment duration (Column 1), internet penetration has a statistically significant negative effect

² The table with complete control variables is shown in the Appendix

(-0.090 , $p < 0.01$), indicating that a one-percentage-point increase in household internet access reduces unemployment duration by 0.09 months. This result is consistent with job-matching theory, which posits that improved digital access lowers search costs and increases job arrival rates. The inclusion of lagged control variables in the second specification further tests for endogeneity and the stability of this effect.

Table 6. Panel fixed-effect result of the impact of internet penetration on youth unemployment duration and unemployment rate

Variables	Youth Unemployment Duration	Youth Unemployment Duration	Unemployment Rate	Unemployment Rate
Internet penetration	-0.090*** (0.034)	-0.135*** (0.038)	-0.026** (0.010)	0.018 (0.014)
_cons	50.780** (24.813)	82.710*** (33.623)	4.255 (6.842)	-11.971 (10.438)
<i>N</i>	1708	1281	1708	1281
<i>R</i> ²	0.573	0.563	0.472	0.395
Lagged control	No	Yes	No	Yes

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable is the average duration of youth unemployment for columns 1 and 2, while the unemployment rate for columns 3 and 4. The years included in the regressions are 2008, 2011, 2014, and 2018. For the second column, the year 2008 is not included. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

In the baseline model for municipal unemployment rates (Column 3), the coefficient for internet penetration is -0.026 ($p < 0.05$), indicating that a one-percentage-point increase in access is associated with a 0.026 percentage point decline in the unemployment rate. However, the coefficient becomes statistically insignificant in the model with lagged controls (Column 4). This attenuation may reflect the more immediate responsiveness of unemployment rates to current conditions, as opposed to delayed influences captured by lagged variables. Additionally, the smaller sample size in the lagged model may increase standard errors, limiting statistical power.

These results yield two key insights. First, internet penetration consistently and significantly reduces youth unemployment duration, reinforcing the role of digital infrastructure in improving job-matching efficiency. Second, while internet access also appears to lower unemployment rates, these effects are less robust in lagged specifications, suggesting they are more sensitive to contemporaneous economic and technological dynamics than past conditions.

6.4. Robustness Check

We continue testing the robustness of the results by using lagged values of the control variables along with lead-lag regression modeling techniques. The inclusion of previous period variables' values helps to mitigate simultaneity bias and reverse causality. By capturing past socio-economic conditions, the analysis minimizes the possibility that current youth unemployment duration affects the controls, allowing for clearer temporal interpretation.

Table 7 reports consistently negative and statistically significant coefficients for internet penetration across all specifications. Internet penetration has a negative impact on youth unemployment duration, according to results from the fixed-effects model containing municipality and year indicators (Column 4). The consistency of the estimates supports the reliability of these results, even though the analysis sample is reduced due to lagging.

Table 7. Estimation result from panel fixed-effect model with lagged controls

Variable	(1)	(2)	(3)	(4)
Internet penetration	-0.117*** (0.026)	-0.165*** (0.027)	-0.124*** (0.039)	-0.135*** (0.038)
Lagged Control	Yes	Yes	Yes	Yes
Municipality FE	No	No	Yes	Yes
Time FE	No	Yes	No	Yes
Constant	34.080*** (7.037)	20.218*** (6.417)	97.244*** (34.824)	82.710*** (33.623)

Obs	1281	1281	1281	1281
Number of municipalities	427	427	427	427
R-squared	0.485	0.557	0.520	0.563

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable in this estimation is the average duration of youth unemployment. The years included in the regressions are 2011, 2014, and 2018. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The model in Column 1 shows that past socio-economic conditions significantly predict current youth unemployment duration, with a coefficient of -0.117 ($p < 0.01$). In Column 2, the coefficient increases to -0.165 after adding time fixed effects, suggesting that accounting for time-specific shocks strengthens the relationship between internet access and shorter unemployment spells. The estimation produces a negative and statistically significant coefficient of -0.124 when municipality fixed effects are included in Column 3. In Column 4, with both time and municipality fixed effects, the association generates a statistically significant coefficient of -0.135 . Across all specifications, the negative relationship between internet penetration and youth unemployment duration supports the hypothesis that improved access reduces search frictions and accelerates employment transitions.

We implement regression models with leads and lags of variables, following the Atasoy (2013) approach for conducting Granger causality tests. The model allows us to determine if present youth unemployment rates influence future internet penetration, and conversely, if internet penetration affects future youth unemployment trends, resulting in a better analysis of the involved causal relationships. Table 8 introduces lagged values of youth unemployment duration and internet penetration. Column 1 shows that the lag of unemployment duration is significantly negative (-0.300 , $p < 0.01$), confirming that past unemployment strongly predicts current outcomes. Internet penetration is also significantly negative (-0.132 , $p < 0.01$), consistent with prior regressions.

Columns 2 and 3 introduce lagged and lead values of internet penetration, respectively. While the lag coefficient is positive and insignificant, the lead coefficient is also insignificant, supporting the directionality of our hypothesis: Current internet penetration affects unemployment duration, but not vice versa. Column 4 removes the lag to confirm the robustness of this lead result.

Table 8. Lag and leads 1

	(1)	(2)	(3)	(4)
Lag 1 duration	-0.300*** (0.035)	-0.296*** (0.035)	-0.377*** (0.070)	-0.377*** (0.070)
Internet	-0.132*** (0.036)	-0.116*** (0.038)	-0.125 (0.090)	-0.127 (0.078)
Lag 1 internet	- -	0.039 (0.024)	0.00264 (0.044)	- -
Lead 1 internet	- -	- -	0.0630 (0.076)	0.0600 (0.057)
Municipality FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Obs	1,281	1,281	854	854
No of Municipality	427	427	427	427

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable in this estimation is the average duration of youth unemployment. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9 reverses the dependent variable, testing whether unemployment duration predicts future internet penetration. The leads of unemployment duration in Columns 3 and 4 are statistically significant. However, the corresponding lags are not, suggesting that the causality does not flow from labor market conditions to infrastructure development. These results reduce concerns about reverse causality and further support our identification strategy.

Table 9. Lag and leads 2

	(1)	(2)	(3)	(4)
Lag 1 internet	-0.147*** (0.180)	-0.147*** (0.180)	-0.044* (0.026)	-0.044* (0.025)
Duration	-0.0916*** (0.026)	-0.0958*** (0.030)	-0.004 (0.054)	-0.021 (0.041)

Lag 1 duration	-	-0.0101	0.021	-
		(0.030)	(0.041)	-
Lead 1 duration	-	-	0.129**	0.115**
			(0.054)	(0.045)
Municipality FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Obs	1281	1281	854	854
No of Municipality	427	427	427	427

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable in this estimation is the internet penetration rate. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Together, the lag-lead and lagged control analyses confirm the robustness of our fixed-effects findings. The association between internet penetration and youth unemployment duration is statistically significant and temporally credible. These results strengthen the case that improvements in digital infrastructure play a causal role in shortening unemployment durations among youth in Indonesia.

6.5. Discussion

The results indicate that greater average internet penetration reduces the average duration of youth unemployment in a municipality, underscoring the importance of digital infrastructure in facilitating job searches. This finding aligns with the DMP framework, where internet penetration increases the job arrival rate by expanding access to job information and echoes evidence from earlier studies examining the labor market impacts of digital infrastructure (Kuhn & Mansour, 2014; Gürtzgen et al., 2021).

During the COVID-19 pandemic, the Indonesian government launched several initiatives to enhance digital infrastructure and access in response to disruptions in employment, education, and public services. These measures reflected both an emergency response and a long-term shift toward a digital economy. The Indonesia Broadband Plan and the Palapa Ring project were reaffirmed as national priorities to extend high-speed internet to underserved areas, particularly

beyond Java. In parallel, the Ministry of Education and Culture allocated Rp 2.3 trillion to subsidize internet bandwidth for 26.8 million students, teachers, and lecturers, ensuring continuity in digital learning and remote work while also supporting access to online job-seeking platforms.

Digital literacy emerged as a foundational component of inclusive labor market participation. The *Siberkreasi* program targeted youth and marginalized groups to build digital competencies relevant to both general usage and employment, including online job applications and digital communication. Through the program, the government collaborated with local administrators and community networks to address disparities between different regions, particularly those outside of Java. These programs serve as essential complements to infrastructure development, helping ensure that digital connectivity translates into effective job search efforts and labor market integration.

Localized connectivity solutions emerged as critical short-term complements to national infrastructure projects. Initiatives such as low-cost Wi-Fi community centers and internet kiosks provide job seekers, especially those lacking home connectivity, with access points to explore employment opportunities. These grassroots initiatives serve as fundamental tools for bridging last-mile digital gaps and help ensure that platforms deliver equitable labor market outcomes.

To strengthen recent developments, the Ministry of Manpower developed digital job-matching platforms like *Karirhub* to connect job seekers with employer databases and streamline recruitment processes. However, barriers such as usability challenges, platform fragmentation, and limited engagement with private-sector actors restrict their effectiveness. Public–private collaboration needs enhancement because aligning the *Karirhub* government portal with private job boards will create a more robust labor market information system, which enhances efficiency and increases digital job matching across various demographics.

While enhancing digital matching platforms is essential for reducing search frictions, structural economic conditions also play a critical role in shaping youth labor market outcomes. Higher regional income levels, indicated by GRDP, support faster job transitions by improving labor market absorptive capacity. Higher average daily wages provide job seekers with greater financial flexibility, allowing them to extend their search and secure better employment matches. Meanwhile, a larger presence of hospitality sector activities seems to encourage seasonal job-seeking behavior, as individuals postpone employment decisions in anticipation of more desirable vacancies.

Lagged control variables further enhance the analysis by addressing potential endogeneity through the consideration of prior socio-economic conditions. Notably, the formal employment rate only becomes significant in the lagged model, suggesting that its impact on youth unemployment duration is gradual. The results indicate that improvements in formal sector growth and the implementation of policies require substantial time to stabilize labor market conditions and enhance job-matching performance. The lagged model also reveals that the proportion of educated individuals is significant, illustrating how education influences job search activities, although over longer periods. Higher levels of education typically necessitate job seekers to spend more time searching for employment due to increased selectivity; however, this time-based effect emphasizes the need for educational growth to align with labor market trends.

The research results reveal multiple aspects of regional demographic characteristics that influence employment searches. The findings indicate that urban agglomerations do not lead to quicker job matching, contrary to prior expectations. Individuals experience longer durations of unemployment in areas with high population density. The contradictory findings may reflect intense local labor competition, as well as an inadequate job market supply for the youth workforce. Young applicants may face unequal disadvantages due to their skill levels and

experience not aligning with the competitive standards of crowded labor markets.

Improved internet penetration is associated with a reduction in the overall municipal unemployment rate and its impact on the duration of youth unemployment. These broader implications for the labor market reinforce the role of digital infrastructure in reducing search frictions and facilitating employment. The study results align with earlier findings (Atasoy, 2013; Bai, 2017) and reflect similar patterns in Indonesia, as reported by Salsabila and Oktora (2022), where broadband expansion has been linked to improved employment outcomes.

In addition to the role of internet penetration, several control variables consistently contribute to variations in both youth unemployment duration and unemployment rates, highlighting important patterns across municipal labor market outcomes. Notably, the percentage of households with higher education emerges as a significant factor in both models, positively associated with unemployment outcomes. This finding suggests that regions with higher educational attainment may experience elevated unemployment rates and longer unemployment durations. One potential explanation lies in the reservation wage, the minimum wage at which an individual is willing to accept a job offer. Individuals with higher educational attainment often have greater aspirations for quality employment. They are more likely to hold out for jobs that match their qualifications and expectations, thereby raising their reservation wage. While this selectivity can lead to better long-term matches in employment, it may also result in prolonged job search durations and temporary structural mismatches, particularly in regions with limited high-skilled job opportunities. This pattern highlights the dual-edged nature of higher education in labor markets, where aspirations for higher-quality jobs may inadvertently contribute to increased unemployment rates and longer job search periods. This pattern is consistent with findings from Friska and Damayanti (2021) and Pasay and Indrayanti (2012), highlighting how higher educational attainment can lead to prolonged job search due to higher reservation wages and aspirations for better-

quality jobs. These dynamics are further supported by Sukanti and Sulistyanningrum (2022), who demonstrate that overeducated Indonesian workers, particularly younger cohorts, tend to face wage penalties and employment mismatches, underscoring the structural inefficiencies in aligning educational output with labor market demands.

Despite the methodological rigor of this study, several limitations warrant consideration. First, the instrumental variable, i.e., terrain slope interacted with year dummies, fails to meet the critical threshold for strong identification in several specifications, limiting the reliability of causal inferences drawn from the IV estimates. Accordingly, greater interpretive weight is placed on the fixed-effects models. Second, while fixed-effects estimations control for time-invariant unobserved heterogeneity, they cannot fully address potential bias from time-varying unobservables. Third, using municipality-level aggregates prevents analysis of within-region heterogeneity and individual-level job search behaviors. Finally, the measure of internet access does not distinguish between access types (e.g., mobile versus broadband), which may obscure significant variations across demographic groups and geographic contexts.

Expanding internet penetration should be a policy priority, as it is linked to shorter durations of youth unemployment and lower overall unemployment rates, especially in regions where job search frictions remain high. Integrating digital job-matching services with existing online platforms and government employment portals can further optimize job searches by reducing search costs and enhancing employer-employee linkages.

Given that higher education is linked to longer unemployment durations and higher unemployment rates, policies must address structural mismatches between educational systems and labor market needs. Strengthening vocational training, expanding digital literacy programs, and promoting collaboration between industry and academia can help align educational outcomes with job market conditions,

ensuring that youth are equipped with skills relevant to an increasingly digital economy.

Other control variables also show significant associations with labor market outcomes. Higher provincial minimum wages and increased female labor force participation rates correlate with lower unemployment rates, suggesting that stronger regional economies and gender-inclusive labor policies contribute to broader employment improvements. Additionally, the connection between e-kiosk availability and reduced unemployment rates indicates that enhanced digital access points may aid job searches, particularly in rural or underserved areas.

To reinforce the credibility of our findings, we conducted robustness checks that incorporate lagged control variables and lead-lag specifications. Including lagged socio-economic variables helps address potential endogeneity by isolating prior conditions that influence both internet access and labor market outcomes. Consistent with Atasoy (2013), lead-lag regressions indicate that past unemployment duration predicts current outcomes, while future values of internet penetration are insignificant, supporting the assumed direction of causality.

Overall, the fixed-effects panel models provide robust evidence supporting the beneficial impact of internet penetration on reducing the duration of youth unemployment. The introduction of lagged control variables further strengthens the robustness of our findings by addressing concerns about endogeneity. Given the weak instrument diagnostics, we prioritize the fixed-effect models as the more reliable source of inference.

7. Conclusion

We examine how access to the internet affects the duration of youth unemployment across different municipalities in Indonesia, drawing on panel data collected between 2008 and 2018. The analysis reveals a consistent pattern: Areas

with greater internet availability tend to experience shorter durations of youth unemployment and lower unemployment rates overall. These results echo core ideas from job-matching theory, particularly the role of digital infrastructure in reducing search frictions, improving the chances of finding work, and facilitating smoother transitions into jobs.

These findings offer clear policy implications for addressing Indonesia's youth unemployment challenges. While initiatives like the Indonesia Broadband Plan and Palapa Ring have expanded digital connectivity, greater investment is needed to close municipal-level disparities. Programs that further enhance youth employability by building digital literacy that aligns with job market needs and integrating digital job-matching portals with private platforms can improve search efficiency and labor market access. Complementary reforms, e.g., expanding vocational training and fostering closer industry-academia collaboration, are critical for resolving structural mismatches between education output and labor demand.

Beyond the primary effects, this study identifies key structural factors, such as regional income levels, labor formality, population density, and digital access points, that shape unemployment dynamics. One notable point is how education can be a double-edged sword. On one hand, it signals that an individual is qualified; on the other hand, it can lead people to hold out for better-paying jobs, especially in areas where high-skilled positions are limited. These trends suggest that it is insufficient to focus on one area alone: Digital infrastructure, economic development, and education need to collaborate to demonstrate a commitment to making the labor market more resilient.

While the study provides robust empirical evidence, its municipality-level focus limits the exploration of individual-level behaviors and differentiated internet usage. Future research should utilize individual-level panel data to investigate heterogeneous effects, examine specific job search behaviors, and differentiate impacts between mobile and fixed broadband internet access. Given the rise of

algorithmic job matching and remote work, further research is essential to understand how digital infrastructure continues to reshape employment processes.

Ultimately, this study demonstrates empirical evidence that internet access is crucial in influencing youth labor market outcomes. By illustrating how digital infrastructure can assist young people in transitioning into work more smoothly, the findings establish a foundation for practical, inclusive, and data-driven labor market policies, especially in developing economies.

References

- Atasoy, H. (2013). The effects of broadband internet expansion on labor market outcomes. *ILR Review*, 66(2), 315–345.
<https://doi.org/https://doi.org/10.1177/001979391306600202>
- Autor, D. H. (2001). Wiring the labor market. *Journal of Economic Perspectives*, 15(1), 25–40. <https://doi.org/10.1257/jep.15.1.25>
- Bai, Y. (2017). The faster, the better? The impact of internet speed on employment. *Information Economics and Policy*, 40, 21–25.
<https://doi.org/10.1016/j.infoecopol.2017.06.004>
- Başol, O., Sevgi, H., & Yalçın, E. C. (2023). The effect of digitalization on youth unemployment for EU countries: Treat or threat? *Sustainability (Switzerland)*, 15(14), 1–15. <https://doi.org/10.3390/su151411080>
- Bhuller, M., Kostøl, A., & Vigtel, T. C. (2020). How broadband internet affects labor market matching. In *Discussion Paper Series* (Issue 12895).
<https://doi.org/10.2139/ssrn.3525222>
- Bloom, D. E., Canning, D., & Sevilla, J. (2003). *The demographic dividend: a new perspective on the economic consequences of population change*. RAND.
http://www.rand.org/content/dam/rand/pubs/monograph_reports/2007/MR1274.pdf
- Boršič, D., & Kavkler, A. (2009). Modeling unemployment duration in Slovenia using Cox regression models. *Transition Studies Review*, 16(1), 145–156.
<https://doi.org/10.1007/s11300-009-0053-6>
- Brück-Klingberg, A., Burkert, C., Garloff, A., Seibert, H., & Wapler, R. (2011). *Does higher education help immigrants find a job? A survival analysis* (No. 6; IAB-Discussion Paper). <https://hdl.handle.net/10419/57443> Standard-Nutzungsbedingungen:
- Choi, E. J. (2023). Does the internet help the unemployed find jobs? *Information Economics and Policy*, 62, 101017. <https://doi.org/10.1016/j.infoecopol.2023.101017>
- Czernich, N. (2014). Does broadband internet reduce the unemployment rate? Evidence for Germany. *Information Economics and Policy*, 29, 32–45.
<https://doi.org/10.1016/j.infoecopol.2014.10.001>
- Denzer, M., Schank, T., & Upward, R. (2021). Does the internet increase the job finding rate?

- Evidence from a period of expansion in internet use. *Information Economics and Policy*, 55, 100900. <https://doi.org/10.1016/j.infoecopol.2020.100900>
- Dettling, L. J. (2017). Broadband in the labor market: The impact of residential high-speed internet on married women's labor force participation. *ILR Review*, 70(2), 451–482. <https://doi.org/10.1177/0019793916644721>
- Fabritz, N. (2013). The impact of broadband on economic activity in rural areas: Evidence from German municipalities. *Ifo Working Paper*, 166.
- Flek, V., Hála, M., & Mysíková, M. (2015). Duration dependence and exits from youth unemployment in Spain and the Czech Republic. *Economic Research-Ekonomska Istraživanja*, 28(1), 1063–1078. <https://doi.org/10.1080/1331677X.2015.1084239>
- Fougère, D., Kramarz, F., & Pouget, J. (2009). Youth unemployment and crime in France. *Journal of the European Economic Association*, 7(5), 909–938. <https://doi.org/10.1162/JEEA.2009.7.5.909>
- Friska, M., & Damayanti, A. (2021). The effect of overeducation on unemployment duration in Indonesia. *Jurnal Ekonomi Dan Statistik Indonesia*, 1(1), 1–13. <https://doi.org/10.11594/jesi.01.01.01>
- Gürtzgen, N., Diegmann, A., Pohlen, L., & van den Berg, G. J. (2021). Do digital information technologies help unemployed job seekers find a job? Evidence from the broadband internet expansion in Germany. *European Economic Review*, 132, 103657. <https://doi.org/10.1016/j.eurocorev.2021.103657>
- Hasan, Z., & Sasana, H. (2020). Determinants of youth unemployment rate in Asean. *International Journal of Scientific and Technology Research*, 9(3), 6687–6691. <https://www.ijstr.org/final-print/mar2020/Determinants-Of-Youth-Unemployment-Rate-In-Asean.pdf>
- Hayes, A., & Setyonaluri, D. (2015). Taking advantage of the demographic dividend in Indonesia: A brief introduction to theory and practice. In *Policy Memo* (Issue April). https://indonesia.unfpa.org/sites/default/files/pub-pdf/Buku_Policy_Brief_on_Taking_Advantage_on_Demographic_Dividend_02c_%282015%29_0.pdf

- Hilker, L. M., & Fraser, E. (2009). Youth exclusion, violence, conflict and fragile states. In *Social Development Direct* (Vol. 18, Issue 2).
<https://linkasea.pbworks.com/f/McLean+Kilker,+Lyndsay+&+Erika+Fraser+April+2009.pdf>
- Ismail, Z., & Kollamparambil, U. (2015). Youth unemployment duration and competing exit states: What hides behind long spells of black youth unemployment in South Africa? *African Development Review*, 27(3), 301–314. <https://doi.org/10.1111/1467-8268.12150>
- Jin, X., Ma, B., & Zhang, H. (2023). Impact of fast internet access on employment: Evidence from a broadband expansion in China. *China Economic Review*, 81(866), 102038. <https://doi.org/10.1016/j.chieco.2023.102038>
- Kolko, J. (2012). Broadband and local growth. *Journal of Urban Economics*, 71(1), 100–113. <https://doi.org/10.1016/j.jue.2011.07.004>
- Kuhn, P., & Mansour, H. (2014). Is internet job search still ineffective? *The Economic Journal*, 124(581), 1213–1233. <https://doi.org/10.1111/ecoj.12119>
- Kuhn, P., & Skuterud, M. (2004). Internet job search and unemployment durations. *The American Economic Review*, 94(1), 218–232. <https://doi.org/https://doi.org/10.1111/ecoj.12119>
- Metu, A. G., Ajudua, E., Eboh, I., Ukeje, C., & Madichie, C. (2020). Ending youth unemployment in Sub-Saharan Africa: Does ICT development have any role? *African Development Review*, 32(S1), S20–S31. <https://doi.org/10.1111/1467-8268.12479>
- Pasay, N. H. A., & Indrayanti, R. (2012). Unemployment, job search duration, and reservation wage of educated labor force. *Jurnal Ekonomi Dan Pembangunan Indonesia*, 12(2). <https://doi.org/10.21002/jepi.v12i2.03>
- Petreski, M., Mojsoska-blazevski, N., & Bergolo, M. (2017). Labor-market scars when youth unemployment is extremely high : Evidence from Macedonia. *Eastern European Economics*, 55(2), 168–196. <https://doi.org/10.1080/00128775.2016.1261631>
- Pissarides, C. A. (2000). *Equilibrium unemployment theory* (2nd Ed.). Cambridge: The MIT Press.

- Raphael, S., & Winter-Ebner, R. (2001). Identifying the effect of unemployment on crime. *The Journal of Law & Economics*, 44(1), 259–283.
<https://doi.org/https://doi.org/10.1086/320275>
- Rezki, J. F. (2023). Does the mobile phone affect social development? Evidence from Indonesian villages. *Telecommunications Policy*, 47(3), 102503.
<https://doi.org/10.1016/j.telpol.2023.102503>
- Salsabila, R., & Oktora, S. I. (2022). The impact of broadband access on unemployment rate in Indonesia 2016-2019. *The Asian Journal of Business Environment (AJBE)*, 12(3), 23–30. <https://doi.org/10.13106/ajbe.2022.vol12.no3.23>
- Sitompul, N. K., & Athoillah, M. (2023). Indonesia's youth unemployment rate: Evidence from Sakernas data. *Journal of International Conference Proceedings*, 6(1), 347–357.
<https://doi.org/10.32535/jicp.v6i1.2346>
- Stockinger, B. (2019). Broadband internet availability and establishments' employment growth in Germany: Evidence from instrumental variables estimations. *Journal for Labour Market Research*, 53(1). <https://doi.org/10.1186/s12651-019-0257-0>
- Sukanti, N., & Sulistyaningrum, E. (2022). Mismatch effect between education, workers, and occupations on the labor market in Indonesia. *Southeast Asian Journal of Economics*, 10(December), 103–133. <https://so05.tci-thaijo.org/index.php/saje/article/view/262487/176418>
- Tangtipongkul, K., & Wangmo, D. (2018). Determinants of unemployment: Characteristics and policy responses in Bhutan. *Southeast Asian Journal of Economics*, 5(2), 27–48.
<https://so05.tci-thaijo.org/index.php/saje/article/view/109468/86082>

Appendix

Table A.1 Two-stage least squares (2SLS) estimation results for youth unemployment duration and unemployment rate

Variables	Second-Stage Regression Average duration of youth unemployment (in months)	First-Stage Regression Percentage of households who use the internet	Second-Stage Regression Unemployment rate	First-Stage Regression Percentage of households who use the internet
Percentage of households with internet access	-0.506** (0.204)		-0.144* (0.079)	
Logarithm of gross regional domestic product	-3.045** (1.536)	-1.574 (1.532)	-0.016 (0.379)	-1.574 (1.532)
Provincial minimum wage (in Indonesian Rupiah)	0.000 (0.000)	0.000 (0.000)	-0.000** (0.000)	0.000 (0.000)
Population density (people per km ²)	0.001 (0.000)	0.001** (0.000)	-0.000 (0.000)	0.001** (0.000)
Logarithm of total population in the municipality	0.709 (1.644)	1.420 (1.599)	0.170 (0.501)	1.420 (1.599)
Average real daily wage (in Indonesian Rupiah)	0.000** (0.000)	0.000*** (0.000)	0.000 (0.000)	0.000*** (0.000)
Percentage of households with higher education	0.036 (0.065)	0.199*** (0.047)	0.053** (0.021)	0.199*** (0.047)
Percentage of male youth in the population	0.365** (0.183)	0.247 (0.175)	0.078 (0.059)	0.247 (0.175)
Rate of formal employment	-0.091* (0.046)	-0.116*** (0.036)	-0.004 (0.016)	-0.116*** (0.036)
Female labor force participation rate	-0.009 (0.044)	0.060* (0.032)	-0.036*** (0.012)	0.060* (0.032)
Percentage of villages in valley areas	-0.033 (0.023)	-0.029 (0.020)	-0.007 (0.006)	-0.029 (0.020)
Percentage of villages with hospitality services	0.141*** (0.048)	0.057 (0.052)	-0.014 (0.014)	0.057 (0.052)
Percentage of villages with traditional markets	-0.008 (0.029)	-0.007 (0.027)	0.022** (0.009)	-0.007 (0.027)
Percentage of villages with stores	-0.052 (0.033)	-0.090*** (0.028)	-0.011 (0.009)	-0.090*** (0.028)
Percentage of villages with food and beverage services	0.027 (0.025)	0.027 (0.020)	0.016** (0.007)	0.027 (0.020)
Percentage of villages dominated by services sector	-0.003 (0.034)	-0.017 (0.046)	0.008 (0.013)	-0.017 (0.046)
Percentage of villages	-0.048	-0.107*	-0.018	-0.107*

dominated by trade sector	(0.049)	(0.060)	(0.015)	(0.060)
Percentage of villages with strong internet signal	-0.041 (0.029)	-0.062*** (0.023)	-0.007 (0.008)	-0.062*** (0.023)
Percentage of villages with e-kiosks	0.116** (0.055)	0.248*** (0.020)	0.012 (0.020)	0.248*** (0.020)
Percentage of villages with fixed-line internet	0.028 (0.017)	0.030* (0.016)	0.013** (0.006)	0.030* (0.016)
Percentage of villages offering job training programs	0.000 (0.011)	0.021* (0.012)	0.0143*** (0.004)	0.021* (0.012)
Year dummy: 2011	4.371* (2.616)	13.73*** (1.648)	1.489 (0.984)	13.73*** (1.648)
Year dummy: 2014	4.847 (3.543)	17.88*** (2.120)	1.285 (1.330)	17.88*** (2.120)
Year dummy: 2018	-3.278 (3.411)	14.20*** (2.616)	0.691 (1.206)	14.20*** (2.616)
Average Terrain Slope X Year 2011		-0.019*** (0.004)		-0.019*** (0.004)
Average Terrain Slope X Year 2014		-0.017*** (0.004)		-0.017*** (0.004)
Average Terrain Slope X Year 2018		-0.010*** (0.003)		-0.010*** (0.003)
<i>N</i>	1708	1708	1708	1708
<i>F</i>	87.69	7.10	41.16	7.10

Notes: Standard errors are in parentheses and are clustered by municipality to account for heteroskedasticity and within-group correlation. The dependent variables are youth unemployment duration (in months) and unemployment rate (as a percentage). The instrumental variable is the interaction between average terrain slope and year dummies for 2011, 2014, and 2018. All models include municipality and year fixed effects, with 2008 as the reference year. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

Table A.2 Panel fixed-effect results for the impact of internet penetration on youth unemployment duration and unemployment rate

Variables	Youth Unemployment Duration	Youth Unemployment Duration	Unemployment Rate	Unemployment Rate
Percentage of households with internet access	-0.090*** (0.034)	-0.135*** (0.038)	-0.026** (0.010)	0.018 (0.014)
Logarithm of gross regional domestic product	-2.433** (1.086)	-0.211 (0.990)	0.157 (0.284)	0.572 (0.356)
Provincial minimum wage (in Indonesian Rupiah)	-0.000 (0.000)	-0.000 (0.000)	-0.000** (0.000)	-0.000* (0.000)
Population density (people per km ²)	-0.000	0.001*	-0.000*	-0.000**

	(0.000)	(0.000)	(0.000)	(0.000)
Logarithm of total population in the municipality	-0.164 (1.575)	-4.640 (3.036)	-0.077 (0.476)	0.890 (0.776)
Real daily wage (in Indonesian Rupiah)	0.000** (0.000)	0.000*** (0.000)	-0.000** (0.000)	-0.000 (0.000)
Percentage of households with higher education	-0.043 (0.048)	0.102* (0.058)	0.030** (0.013)	0.028 (0.018)
Percentage of male in the population	0.245 (0.166)	-0.096 (0.163)	0.044 (0.050)	0.025 (0.064)
Rate of formal employment	-0.046 (0.035)	-0.086* (0.045)	0.008 (0.013)	-0.005 (0.015)
Female labor force participation rate	-0.042 (0.041)	0.043 (0.037)	-0.045*** (0.009)	-0.023* (0.013)
Percentage of villages in valley areas	-0.023 (0.020)	0.004 (0.033)	-0.004 (0.005)	-0.026*** (0.006)
Percentage of villages with hospitality services	0.114** (0.044)	-0.043 (0.053)	-0.022 (0.014)	-0.035 (0.025)
Percentage of villages with traditional markets	-0.006 (0.027)	0.040 (0.033)	0.023** (0.009)	-0.011 (0.011)
Percentage of villages with stores	-0.015 (0.027)	-0.065** (0.031)	-0.000 (0.007)	0.000 (0.009)
Percentage of villages with food and beverage services	0.018 (0.022)	-0.015 (0.026)	0.013* (0.007)	-0.009 (0.009)
Percentage of villages dominated by services sector	-0.011 (0.034)	0.030 (0.029)	-0.011 (0.012)	0.021 (0.015)
Percentage of villages dominated by trade sector	0.001 (0.036)	0.005 (0.036)	-0.004 (0.012)	0.038** (0.018)
Percentage of villages with strong internet signal	-0.017 (0.024)	-0.014 (0.027)	0.000 (0.006)	-0.014* (0.008)
Percentage of villages with e-kiosks	0.010 (0.014)	0.010 (0.016)	-0.017*** (0.006)	-0.017*** (0.006)
Percentage of villages with fixed-line internet	0.012 (0.014)	0.043* (0.024)	0.009* (0.005)	0.004 (0.007)
Percentage of villages offering job training programs	-0.007 (0.001)	0.000 (0.013)	0.012*** (0.004)	-0.000 (0.006)
Year dummy: 2011	-0.328 (1.163)		0.156 (0.328)	
Year dummy: 2014	-1.700 (1.575)	-0.956 (1.110)	-0.572 (0.444)	-1.424*** (0.419)
Year dummy: 2018	-8.566*** (1.968)	-8.917*** (1.466)	-0.809 (0.612)	-1.805*** (0.575)

<i>Cons</i>	50.780* (24.813)	82.709** (33.622)	4.256 (6.842)	-11.97 (10.44)
<i>N</i>	1708	1,281	1,708	1,281
<i>F</i>	123.26	65.74	42.62	22.28
<i>Lagged Control</i>	No	Yes	No	Yes

Notes: Standard errors are in parentheses and are clustered by municipality. The dependent variable is the average duration of youth unemployment for columns 1 and 2, while the unemployment rate for columns 3 and 4. The years included in the regressions are 2008, 2011, 2014, and 2018. For the second column, the year 2008 is not included. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.