ECOCYCLES
ISSN 2416-2140

OPEN ACCESS
Scientific journal of the
European Ecocycles Society



Ecocycles, Vol. 12, No. 2, pp. 1-14 (2026)
DOI: 10.19040/ecocycles.v12i2.697

RESEARCH ARTICLE

Limited Association Between Green Transition and Labor Formalization: Evidence from Indonesia's Dual Labor Market

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Abstract – The green transition is increasingly regarded as a significant issue aligned with SDG commitments and net-zero objectives. Research is beginning to connect the green transition to the labor market, yet it remains confined to a single labor-market framework. This research aims to investigate how the green transition is associated with the probability of formal employment in a dual labor market framework. This study employs logistic regression on data from the 2024 weighted National Labor Force Survey (SAKERNAS), which includes 526,113 respondents. The logistic regression reveals that the green transition positively and significantly associated with formal employment (adjusted odds ratio = 1.01; 95% CI: 1.01-1.02). This result supports the hypothesis, though the association is modest. The discrepancy between the descriptive statistics and the regression indicates that age is a key confounder: older informal workers tend to have higher green transition scores, yet older age reduces the likelihood of formalization. Relative to other predictors, university education (aOR = 2.72), industry sector (aOR = 7.84), and white-collar occupations (aOR = 11.98), the association between green transition and formal employment is comparatively small. The study concludes that while green transition has a positive, albeit limited, association on formalization, policies aimed at formalization should be paired with additional structural measures.

Keywords – Green transition, formal-informal, Indonesia, logistic regression

Received: May 19, 2026 Accepted: July 27, 2026

1. INTRODUCTION

The global transition to a green economy, driven by commitments to the SDGs and net-zero targets, is reshaping labor markets worldwide (Rodríguez-Pose and Bartalucci, 2024; Zhai et al., 2022). The transitions require labor markets to adapt to evolving economic structures. Nevertheless, adjustment mechanisms frequently encounter difficulties in developing countries. The green transition entails not only sectoral transformations but also creates an institutional demand for more formal employment arrangements (Ales et al., 2024; Grazini et al., 2024). Implementing environmental standards, regulatory compliance, emissions reporting, and green financing mechanisms requires a documented production framework that is integrated into legal and fiscal systems (Gold and Tregenna, 2025; Gyamfi et al., 2025). Consequently, the growth of sustainability-oriented economic activity implicitly raises the demand for formal labor (Ding and Hirvilammi, 2024; Grazini et al., 2024). Workers' capacity to meet this demand depends largely on their individual human and social capital, which are often unevenly distributed between formal and informal workers.

In developing countries, the informal sector dominates the labor market, posing a structural barrier to the green transition (Mathieu, 2024; Pal and Das, 2024). Studies have found that the informal sector violates labor standards, hindering compliance with environmental regulations (Bali Swain and Kambhampati, 2023; Chattopadhyay et al., 2010). The informal sector is also associated with lower productivity (Paz, 2021), which limits fiscal capacity, weak tax enforcement (Granda-Carvajal and García-Callejas, 2023), and reduces resources for green investment (Besley and Persson, 2014; Gaspar et al., 2019). In labor-surplus countries such as Indonesia, supply pressures sustain informality, making regulatory tightening more difficult.

The labor market is divided into the primary and secondary segments by the labor market segmentation theory

(Doeringer and Piore, 1971). The primary labor market was one of stable conditions, higher wages, and clear career paths. The secondary market was the opposite. This segmentation is affected by economic, institutional, social, and political factors (Heyes and Yates, 2025). The main sector, now called the formal sector, is characterized by uniform employment practices aligned with global standards on issues such as working conditions, wages, social security, and union representation. However, the informal sector is flexible and result-oriented, and is seldom covered by standardized regulations (Ablaza and Perales, 2025). Such flexibility, although it allows for easier entry and exit from the job market, creates a lack of protection and job insecurity (Galiani and Weinschelbaum, 2012).

This study investigates how the green transition affects the dual labor market between formal and informal. Existing literature on the green transition mainly highlights sectoral changes that arise from a shift toward low-emission economic activities (Shobande, 2022). Studies on the relationship between the green transition and the labor market are scarce. Some studies focus on the emergence of green jobs (Bowen et al., 2018; Liu et al., 2023; Osorio-Aravena et al., 2025), skill biases and workforce transformation (Ahmad et al., 2024; Muller, 2016; Pilipczuk, 2024). Geographically, the green transition also has varying impacts across regions (Jomaa, 2026; Larkin et al., 2024; Lim et al., 2023; Matsumoto and Matsumura, 2022). Yet, research that simultaneously examines labor informality and the context of green transformation remains scarce. Most existing studies focus on advanced economies where informality is marginal, leaving a critical gap in understanding how the green transition shapes formalization dynamics in developing countries with large informal sectors, such as Indonesia.

The idea of a green economy focuses on job responsibility and the sustainability of the environment and therefore requires some organization in work processes, such as task assignment, procedural operations, and outcomes (Thake, 2024). There could be disruptions in the job market when shifting to the idea of a green economy due to differences in skills required and standards to be maintained (Ales et al., 2024). However, the shift is expected to produce some long-term gains, like high earnings for workers, development contributions through taxes, and sustainability of the environment (Barua and Aziz, 2022).

Evidence from low- and middle-income countries shows that the green transition consistently creates renewable energy jobs, though the scale varies. Colombia and Brazil are the main players in the Latin American region, with the largest shares of green jobs, at 19.3% and 16.9%, respectively (International Renewable Energy Agency, 2021). In Colombia, the green transition has had a limited impact on the shift from non-green to green jobs, with green jobs enjoying a 10.6% wage premium over their counterparts (Caiza-Guamán et al., 2025). In Brazil, wind power has experienced explosive growth over the past few years. Jobs were quantified across the manufacturing, installation, and operation stages, with observation of the national manufacture of major components. Estimated wind power growth will generate 90,000 jobs from 2012 to 2016 (Simas and Pacca, 2014). The study in Sub-Saharan Africa links natural-resource rent to higher green-energy adoption. Self-employment and wage/salaried workers cut clean-energy use, while agriculture and services boost it; industrial employment reduces renewable consumption (Okere et al., 2025).

In Vietnam, energy transition generates substantial net positive employment effects, ranging from 218,700 positions (2022–2025) to 727,400 positions (2045–2050), with distinctive temporal and sectoral patterns (Pham et al., 2026). Educational attainment is a key determinant, such that individuals with a tertiary education are more likely to move into green occupations (Duman and Ananian, 2026). In India, the implementation of the green transition provides opportunities for young workers to be more easily absorbed into the labor market (Bhattacharyya, 2024). This transformation is not only about job creation and destruction—it also entails substantial changes in the skills and qualifications required of workers across industries (Ham et al., 2025).

Based on the above-stated theoretical background, this paper examines the influence of the green transition on employment opportunities in the formal sector, with a particular focus on areas undergoing significant transition. Green transition is one of the most relevant research areas. This paper contributes to current research literature in two ways. Firstly, this paper broadens the discussion of labor market preparation for the green transition, drawing on empirical evidence from developing countries such as Indonesia. Secondly, the study's findings have policy implications, emphasizing the importance of effective environmental policies to accelerate the transition. Given the lack of data on the green transition in Indonesia, the study develops a green transition index (Zhai et al., 2022).

This study hypothesizes that the transition to a green economy will alter the distribution of employment across industrial sectors. It argues that the impact of this effect differs by region, as local labor markets respond differently to changes in the demand for green skills and services. In areas affected by the green transition driven by large-scale renewable energy projects, demand for formal employment contracts rises as the need for regulated, documented production processes increases. By contrast, in areas with weaker institutions, job formalization may proceed more slowly, even where green activities are present. The study also points out that the increased need for compliance and certification can increase the barriers to entry for small firms and, therefore, limit job creation in such environments. Critics claim that the green transition will create an excess of low-wage and precarious jobs that do not fully meet the definition of formal employment. However, the general expectation is that the green economy will lead to a more structured and secure labor market in the long run if policies are implemented to address regional disparities. Three

specific mechanisms link the green transition to formalization. First, regulatory compliance: environmental standards require documented and monitored production processes that registered, formal firms can meet more readily than informal ones. Second, reporting and certification requirements: emissions reporting and green certification schemes presuppose formal record keeping that most informal enterprises rarely maintain. Third, skill demand: green occupations increasingly require certified technical skills obtained through formal training pathways, which favor formal employment relationships. The hypothesis is therefore stated as follows:

RH= A higher level of green transition is associated with a higher probability of working in the formal sector, after controlling for individual and regional characteristics.

To test this hypothesis, the study employs a logistic regression model using individual-level survey data and a regional green transition index. The following section describes the data sources, variable measurements, and empirical strategy.

2. Research Methods

This study integrates individual and macro-level variables. The main focus is on the green transition, which is measured at the provincial level. This leads to identical green transition index values for all individuals in the same province and to a nested data structure, necessitating careful handling of standard errors. This study constructs the green transition index following the approach proposed by Zhai et al. (2022). It uses five indicators: industrial structure, reform and openness, investment capacity, government intervention, and environmental regulation. For each indicator, the following proxies are used:

a. Industrial structure (IS) – proportion of tertiary industry output to GDP;
b. Reform and openness (RO) – total foreign investment per capita;
c. Investment capacity (IC) – total fixed-asset investment per capita by the local government;
d. Government intervention – local fiscal expenditures per capita (IDR/Person);
e. Environmental regulation (ER) – environmental governance investment per capita (IDR/Person).

Zhai et al. (2022) used Moran's scores to quantify the spatial dependencies of provincial green transition indicators. By contrast, this study directly constructs an index from provincial sub-indicators and, using principal component analysis (PCA), combines five measures to retain key information and provide an objective assessment of the level of green transition across provinces. The resulting index, referred to hereafter as the Green Transition Index (GTI), achieves a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of 0.639 and significant Bartlett's test of sphericity ($\chi^2 = 190.033$, $p < 0.001$; Appendix Table A.1), confirming that PCA is applicable even though sampling adequacy is only moderate by conventional standards. The five underlying indicators are included because provincial fiscal capacity, investment capacity, and openness are treated, following Zhai et al. (2022), as preconditions for the province's capacity to fund environmental outcomes. This indicator set therefore partly overlaps with general indicators of provincial economic development, a limitation acknowledged in the Discussion section. On the first principal component, which explains 70.3% of total variance (Appendix Table A.2), reform and openness, investment capacity, government intervention, and environmental regulation load positively and substantially (loadings 0.43-0.52), while industrial structure loads negatively (-0.21; Appendix A.3), indicating that the index primarily reflects provincial fiscal, investment, regulatory capacity for green transition rather than the tertiary-sector share of output. The index uses data from 2023 (a 1-year lag) to maintain temporal ordering, while individual labor market outcomes are measured using the SAKERNAS survey in August 2024. The resulting index is standardized to have a mean of zero and a standard deviation of one for ease of interpretation.

The dependent variable is the probability of being formally employed as opposed to informally employed. The variable is coded as 1 for formal and 0 for informal. This study defines formal employment following the definition of International Labour Office (2003). Formal employment is characterized by a written contract, social protection coverage, minimum wage compliance, and adherence to labor regulations. Informal employment lacks a formal contract, social security registration, and job protection. Unemployed individuals and those outside the labor force were excluded from the analysis, as the dependent variable is binary (formal vs. informal). Informal workers include self-employed individuals, those assisted by non-permanent workers, casual workers in agriculture and non-agriculture, and unpaid family workers. Statistics Indonesia uses this definition in its recent publication (BPS-Statistics Indonesia, 2024).

This study employs a binary logistic regression model. Because the key independent variable (GTI) varies only at the provincial level, two important econometric considerations arise. First, the effective sample size for estimating the effect of green transition is the number of provinces, not the number of individuals. Second, standard errors must account for the clustering of individuals within provinces, as individuals from the same province are likely to share unobserved characteristics that affect their employment outcomes. Therefore, this study uses cluster-robust standard errors at the provincial level (Colin Cameron and Miller, 2015). The final logistic regression applies probability weights using [pweight=WEIGHT] to account for SAKERNAS's unequal sampling probabilities, and standard errors are clustered at the provincial level using vce(cluster province) to account for within-province correlation induced by the province-level GTI. Primary sampling units (PSU) structure is not explicitly modeled in the regression because province-level clustering is the appropriate grouping unit when the key explanatory

variable varies only between provinces[1]. The model is specified by the following equation:

$$\log\left(\frac{P(Y_{ij}=1)}{1-P(Y_{ij}=1)}\right) = \beta_0 + \beta_1 \text{Green}_j + X'_{ij}\beta + Z'_j\gamma + \varepsilon_{ij} (1)$$

where $P(Y_{ij} = 1)$ denotes the probability that an individual i residing in the province j is formally employed; Green_j is the composite GTI for the province j; X_{ij} is a vector of individual-level covariates (e.g., age, sex, education, marriage status, occupation, sector); Z_j is a vector of provincial-level covariates (e.g., economic growth and labor force participation rate); and ε_{ij} is the error term. Province fixed effects are not included in the main specification because the GTI is constant within each province, including a full set of province dummies would fully absorb this variation, leaving no within-province variation with which to identify β_1. Instead, observable provincial heterogeneity is controlled for by including Z_j. Economic growth and the labor force participation rate are included as provincial-level controls because they are the standard macro-level correlates of informality identified in the labor economics literature (Banerjee, 2019; La Porta and Shleifer, 2014; Williams and Kedir, 2015). Other candidate provincial variables, such as minimum wage or sectoral GDP composition, were considered but not included, either because they are collinear with components already embedded in the GTI.

The main parameter of interest in logistic regression is the adjusted odds ratio (aOR), which indicates the change in odds of formal employment relative to the baseline for each predictor. An aOR above 1 means a higher probability of formal employment, and an aOR below 1 means a lower probability of formal employment. Because the dependent variable is coded 1 for formal and 0 for informal, an aOR > 1 for a given predictor implies that a higher value of the predictor increases the probability of formal employment. For reliable econometric inference, province-level cluster-robust standard errors are used to account for within-province correlation.

Individual-level data were obtained from the National Labor Force Survey (Survei Angkatan Kerja Nasional/SAKERNAS), conducted in August 2024 by Statistics Indonesia (BPS). SAKERNAS is a biannual household survey conducted in February and August. The August 2024 wave included 307,880 households, more than the February wave, so it is representative at the district level. The dataset provides comprehensive information on demographic characteristics, educational attainment, job attributes, and recent job-search activity.

SAKERNAS used a two-stage random sampling method with a population framework based on the 2020 population census. In the first stage, the entire population was divided into rural and urban categories. In the second stage, households were divided based on PSUs. Households within a PSU were randomly selected, and one household member was randomly selected to represent the household. Therefore, the analysis adjusted for PSU clustering to obtain robust standard errors, but did not account for stratification effects.

The unit of analysis included all working-age individuals aged 15 or older who were employed at the time of the survey. Individuals who were unemployed, not in the labor force, or had missing data were excluded, resulting in a final analytical sample of 526,113 respondents. With total 38 provincial clusters, inference relies on cluster-robust standard errors. Colin Cameron and Miller (2015) treat 30-50 clusters as a rough practical guideline rather than a hard minimum. Each province contributes on average ~13,845 observations and provinces sample sizes are relatively balanced. Simulation evidence from MacKinnon and Webb (2018) shows cluster-robust variance estimators perform well with $G \geq 20$ when clusters are of comparable size. Stata's vce(cluster) applies the finite-sample correction $G/(G-1)\times(N-1)/(N-K)$ automatically, making inference conservative rather than anti-conservative.

[1] The Stata estimation command is: logistic formal green age age2 i.sex i.married i.education i.sector i.occupation i.urban i.region growth lfpr [pw=WEIGHT], vce(cluster province)

Table 1 Variable Measurements

Variable	Description	Measurement
Employment status	Respondent's employment status, formal or informal worker	Nominal; 1=formal; 0= otherwise (informal)
GTI	Provincial green transition index (GTI)	Continuous
Age	The length of time a respondent has lived from the date of birth to the date of enumeration, expressed in completed years.	Continuous
Age^2	Squared form of the variable Age divided by 100	Continuous
Sex	Respondent's biological state or identity, classified into male or female categories, based on physical appearance and population documents.	Categorical scale: 1= Male; 0= otherwise (female)
Married	Respondent's marital status is currently married, in accordance with the laws/regulations in force in Indonesia, including both state and religious law.	Categorical scale: 1= Currently married; 0= otherwise (not yet married)
Divorced	Respondent's marriage status is currently divorced/widowed, based on the laws/regulations in force in Indonesia, both state law and religious law.	Categorical scale: 1= Divorced/widowed; 0= otherwise (not yet married)
Urban	Respondent's residence classification	Categorical scale: 1=urban; 0=otherwise (rural)
Junior high school	Respondent's highest level of formal education that has successfully completed at the junior high school level	Categorical scale: 1= Junior high school; 0= otherwise (elementary school or below)
Senior high school	Respondent's highest level of formal education that has successfully completed at the senior high school level	Categorical scale: 1. Senior high school; 0= otherwise (elementary school or below)
University	Respondent's highest level of formal education that has successfully completed at the university level	Categorical scale: 1= university; 0= otherwise (elementary school or below)
Industry	Respondent's job sector for the last week was industry	Categorical scale: 1 = industry; 0= otherwise (agriculture)
Service	Respondent's job sector for the last week was service	Categorical scale: 1 = service; 0 = otherwise (agriculture)
Other sector	Respondent's job sector for the last week was others	Categorical scale: 1 = other sector; 0 = otherwise (agriculture)
White-collar	Respondent's occupational classification based on type of work (professional, technical, and administrative occupations)	Categorical scale: 1 = white-collar; 0 = otherwise
Sumatra	Respondent's residence is on Sumatra Island	Categorical scale: 1 = Sumatra island; 0 = otherwise (Java)
Bali and Nusa Tenggara	Respondent's residence is on the Bali and Nusa Tenggara islands	Categorical scale: 1 = Bali and Nusa Tenggara island; 0 = otherwise (Java)
Kalimantan	Respondent's residence is on Kalimantan Island	Categorical scale: 1 = Kalimantan island; 0 = otherwise (Java)
Sulawesi	Respondent's residence is on Sulawesi Island	Categorical scale: 1 = Sulawesi island; 0 = otherwise (Java)
Maluku and Papua	Respondent's residence is on the Maluku and Papua islands	Categorical scale: 1 = Maluku and Papua islands; 0 = otherwise (Java)
Growth	Provincial economic growth in 2023	Continuous
Labor force participation rate	Provincial labor force participation percentage in 2023	Continuous

3. Results and Discussion

3.1 Descriptive Statistics

Descriptive statistics for categorical data (Table 2) show that informal workers dominate the Indonesian labor market, reaching 57.95%. This fact aligns with the findings of Hohberg and Lay (2015) and Gindling (2018). Based on gender, men dominate in both sectors, with 65.7% in the informal sector and 56.37% in the formal sector. The married group has the largest share by marital status, with 65.37% in the formal sector and 74.15% in the informal sector. In terms of education, more than 70% of formal workers have at least a junior high school education, compared to 30.82% in the informal sector. These figures indicate that formal employment generally requires higher skill levels.

The sectoral indicator implies that the majority of formal workers are employed in services and other non-agricultural sectors, accounting for 71.37%, while more than half of informal workers are engaged in agriculture. Regarding respondents' occupation, 30.61% of formal workers hold white-collar positions, compared to only 2.07% in the informal sector. Regarding residence, 71.2% of formal employees live in urban areas, whereas only 48.15% of informal workers do. Regionally, Java remains the main residence for the workforce. Outside of Java, Sumatra has the largest number of informal workers, but only 19.14% of formal workers live there.

Table 2. Descriptive Statistics for Categorical Variable

Variable	Category	Formal	Informal	Overall
Sex (ref: female)	Male	65.7	56.37	58.36
Marriage status (ref: not yet married)	Married	65.37	74.15	72.49
	Divorced	6.25	11.15	9.31
Education (ref: elementary school and below)	Junior high school	13.79	20.39	16.98
	Senior high school	43.61	26.61	30.97
	University	24.7	4.21	13.07
Sector (ref: agriculture)	Industry	20.13	9.27	13.83
	Service	36.88	19.50	26.81
	Other sectors	34.49	28.78	31.18
Occupation (ref: blue-collar)	White-collar	30.61	2.07	14.07
Residence classification (ref: rural)	Urban	71.2	48.15	57.84
Region (ref: Java)	Sumatra	19.14	21.05	20.25
	Bali and Nusa Tenggara	4.99	6.87	6.08
	Kalimantan	7.05	5.32	6.05
	Sulawesi	6.55	7.66	7.19
	Papua	3.16	4.48	3.93

Note: formal percentage 42.05%; total observation 526,113; analytical survey weight applied

Descriptive statistics for three categories of workers, namely the formal sector, the informal sector, and the combined sample, are shown in Table 3 using 526,113 survey-weighted observations. The analysis focuses on green transition, age, age squared, growth, and the labor force participation rate. The highest mean value for the green transition is found for informal workers at 0.44, compared with the combined sample (0.40) and formal workers (0.35). The standard deviation of informal workers (2.05) is lower than that observed for formal workers (2.11), indicating a smaller spread for the former. The minimum value (-1.83) and maximum value (7.80) are the same for all samples.

Informal workers have a higher mean age (44.81 years) relative to formal workers (37.20 years) and the combined group (41.61 years). Informal workers have a higher mean age^2 (22.14) than formal workers (16.58). Informal workers have an almost identical mean growth value (4.99) to the other two groups, but a higher standard deviation of 1.14. Informal workers have a higher labor force participation rate (71.08) than formal workers (70.39) and the combined group (70.79). The above observations confirm differences in the age composition of the two categories of workers regarding the green transition. Growth figures remain relatively consistent across the board.

Table 3. Descriptive Statistics for Continuous Variable

Variable	Mean	Std dev	Min	Max
Formal				
GTI	0.35	2.11	-1.83	7.80
Age	37.20	12.33	15.00	98.00
Age^2	16.58	10.19	2.25	96.04
Growth	4.99	1.05	0.77	14.44
Labor force participation rate	70.39	3.37	65.10	77.50
Informal				
GTI	0.44	2.05	-1.83	7.80
Age	44.81	15.05	15.00	98.00
Age^2	22.14	13.34	2.25	96.04
Growth	4.99	1.14	0.77	14.44
Labor force participation rate	71.08	3.32	65.10	77.50
Overall				
GTI	0.40	2.08	-1.83	7.80
Age	41.61	14.46	15.00	98.00
Age^2	19.56	14.59	2.25	96.04
Growth	4.99	1.10	0.77	14.44
Labor force participation rate	70.79	3.36	65.10	77.50

Note: total observation 526,113; analytical survey weight applied

3.2 Logistic Regression Results

Table 4 shows that the GTI, taking into account the effect of individual features (gender, age, marital status, education, economic sector, occupation, and residence type) and macro-level indicators (GDP growth and labor force participation), yields an aOR equal to 1.01, which is highly significant at $p<0.01$. In other words, a one-unit increase in the green transition index leads to a 1.01-fold increase in the probability of having a formal job rather than an informal one. With the corresponding 95% CI of [1.01; 1.02], this suggests that the results support the first hyphothesis. Thus, a higher level of green transition leads to a higher probability of formalization of employment.

It is worth noting that although Table 3 showed that informal workers had higher levels of green transition, this relationship becomes positive when age (which differs markedly between the groups) is included in the model along with other covariates. This means that the spurious correlation found in Table 3 was due to age's negative effect on the probability of holding a formal job. Including age and age squared in the model yields a small but positive net effect of the green transition on the formal employment rate. Apart from the GTI variable, there are many others whose effect on the formal employment rate is considerably higher. In particular, male gender is associated with an aOR equal to 2.32. It means that males are 2.32 times more likely to be employed formally than women, regardless of other variables. The educational background shows a clear gradient, with university graduates almost three times as likely to have formal jobs as those who attended primary school (the corresponding aOR is 2.72).

Occupation is the strongest variable: a white-collar worker is 11.98 times more likely to have a formal job than a blue-collar colleague. Finally, the industrial sector is 7 times more likely to be formalized than the agricultural sector (aOR = 7.84). As for the effect of macro-level variables, GDP growth and labor force participation are associated with a slight reduction in the probability of having a formal job, with an aOR of 0.99, which is statistically significant ($p<0.01$). Compared with Java, most non-Java regions, including Bali and Nusa Tenggara, Sulawesi, and Papua, have lower odds of formal employment (aOR < 1), whereas Sumatra and Kalimantan have higher odds. The logistic regression indicates that the GTI has a small but positive impact on the likelihood of formal-sector employment after controlling for various socio-demographic and economic factors. Figure 1 displays the adjusted odds ratios and 95% confidence intervals for all predictors in the model.

Table 4. Logistic Regression

Variable		aOR	95% CI
GTI		1.01*** (0.01)	[1.01,1.02]
Sex	Female	1.00	
	Male	2.32*** (0.03)	[2.27,2.37]
Age		1.03*** (0.01)	[1.03,1.04]
Age^2		0.94*** (0.03)	[0.93,0.95]
Marriage status	Not yet married	1.00	
	Married	0.82*** (0.02)	[0.79,0.85]
	Divorced	1.08** (0.03)	[1.02,1.14]
Education	Elementary school	1.00	
	Junior high school	1.07*** (0.02)	[1.03,1.10]
	Senior high school	1.74*** (0.03)	[1.70,1.79]
	University	2.72*** (0.07)	[2.60,2.84]
Sector	Agriculture	1.00	
	Industry	7.84*** (0.15)	[7.57,8.12]
	Service	3.23*** (0.06)	[3.12,3.34]
	Other sectors	3.01*** (0.05)	[2.92,3.09]
Occupation	Blue collar	1.00	
	White collar	11.98*** (0.33)	[11.36,12.64]
Residence Classification	Rural	1.00	
	Urban	1.50*** (0.02)	[1.47,1.54]
Region	Java	1.00	
	Sumatra	1.05*** (0.02)	[1.02,1.08]
	Bali and Nusa Tenggara	0.81*** (0.02)	[0.77,0.85]
	Kalimantan	1.55*** (0.03)	[1.50,1.60]
	Sulawesi	0.84*** (0.02)	[0.81,0.87]
	Papua	0.70*** (0.02)	[0.68,0.73]
Growth		0.99*** (0.01)	[0.98,0.99]
Labor force participation rate		0.99*** (0.01)	[0.98,0.99]

*Note: Standard error in parentheses; *** significant at 1%, ** significant at 5%, * significant at 10%; probability survey weight applied. Age^2 is rescaled as $Age^2/100$; aOR = 0.94 [0.93-0.95], indicating that the positive association between age and formal employment attenuates at older ages*

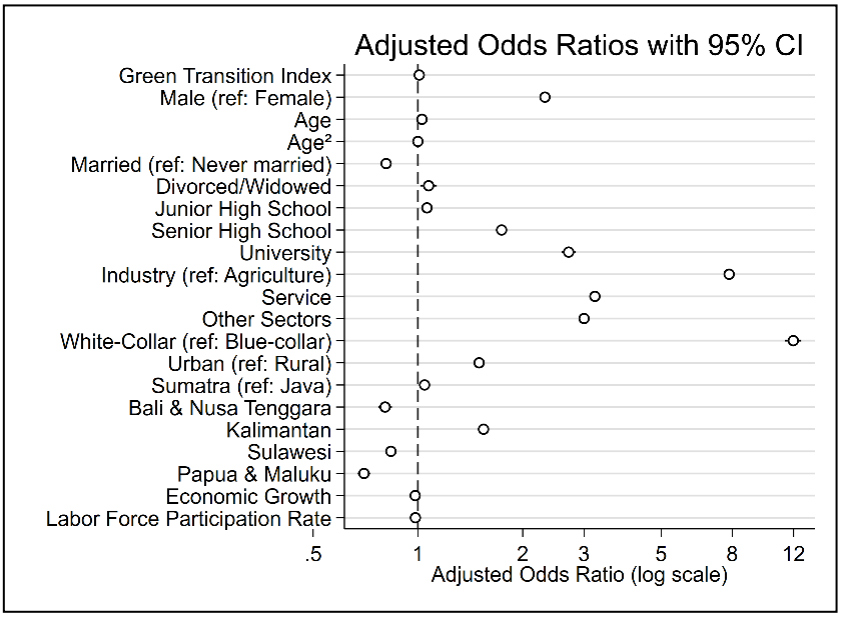


Figure 1. Adjusted Odds Ratios with 95% Confidence Intervals for All Predictors of Formal Employment

4. DISCUSSION

The logistic regression results indicate that the green transition is positively and statistically significantly associated with the likelihood of employment in the formal sector (aOR = 1.01; p<0.01). A cross-country analysis by Causa et al. (2024) revealed that the green transition within the European labor market has advanced only moderately, with a modest shift in the proportion of green jobs over the last decade. This indicates that the modest association observed is consistent with the green transition's incremental nature. Based on these findings, the empirical results support the hypothesis that the green transition promotes formalization, although the substantive association remains limited. This distinction between statistical and substantive significance deserves emphasis. With N = 526,113, statistical power is very high, so even a coefficient corresponding to a 1% change in the odds of formal employment per unit of the index reaches conventional significance; this should not be read as evidence of a strong or policy-relevant green-transition-to-formalization pathway. Relative to education, occupation, and sector, the green transition is a comparatively weak driver of formalization in Indonesia, and its contribution should be understood as a secondary, incremental channel rather than a primary lever for formalization policy. These findings also speak to labor market segmentation theory (Doeringer and Piore, 1971; Heyes and Yates, 2025). Rather than reshaping the boundary between the primary and secondary segments, the green transition appears to operate as an additional, comparatively weak formalization channel that functions within the existing segmentation structure, alongside the conventional drivers of education, occupation, and sector. This suggests that an institutional-environmental demand channel exists in a developing-country dual labor market but does not override the structural determinants that segmentation theory identifies as primary.

The model shows that the age variable is positively associated with the probability of becoming a formal worker, although a smaller association for age squared is also observed for the green transition variable. This finding is consistent with the literature explaining that age is an important factor linking one's participation in the formal sector. Older workers are known for their involvement in traditional, environmentally related sectors such as agriculture (Vona et al., 2015). Conversely, younger workers are known to be a group actively transitioning between the informal and formal sectors.

The logistic model also indicates that the association between green transition and formalization is small (aOR=1.01) compared to other variables, such as white-collar (aOR=11.98) and industrial sector (aOR=7.84). This result is consistent with the literature suggesting that economic structure and job characteristics together are key determinants of labor market formalization, compared to environmental factors alone. Fields (2019) found that the distinction between formal and informal labor markets is more accurately explained by sectoral productivity differences, education levels, and access to regulation and legal protection. Other studies have also found that the green transition was positively associated with employment absorption, although the association was quite small, between 5% and 10% (Chen et al., 2020). The remaining variation is due to structural factors such as industrialization and urbanization, suggesting that formalization strategies should not rely solely on the green transition but should also incorporate broader structural reforms. A related interpretive point concerns the sector coefficients themselves. Because agriculture is the omitted reference

category and is predominantly informal in Indonesia (Table 2), the industry and service coefficients (aOR = 7.84 and 3.23, respectively) should be read as the formalization gap relative to a highly informal baseline, rather than as a "green sector" effect. Because the sector variable is measured at the individual level while the green transition index is measured at the provincial level, the two are separately identified, so this baseline effect does not bias the green transition coefficient.

On macro level variables, the association between GDP growth and formal employment (aOR = 0.99) and labor-force participation (aOR = 0.99), the results are relatively small but statistically significant negative effects on the probability of formal-sector employment, consistent with research by Banerjee (2019) and La Porta and Shleifer (2014). The research notes that in developing economies, the expansion of the informal sector is often accompanied by economic growth, particularly when growth is driven by labor-intensive services, including frequently unregistered services. Increases in labor-force participation typically signal the entry of low-productivity workers, who are more likely to join the informal sector due to lower barriers to entry (Williams and Kedir, 2015). These results are consistent with standard labor economics theory, which holds that the informal sector is a free-entry, free-exit sector. It also confirms that the relationship between growth and formalization is non-linear and highly dependent on regional economic structure.

Based on the results of the logistic regression, some limitations identified in comparable research stem from the cross-sectional design, which limits causal inference. Longitudinal data are required to determine whether the green transition drives formalization or vice versa, especially since formal-sector workers already have greater access to green training and technology (Dunan et al., 2025). Additionally, varying definitions of the green transition across studies complicate direct comparisons. While this study measures the green transition using sectoral economic output, other research (Vona et al., 2018) assesses it at the level of individual jobs. Despite these constraints, the large sample size (N = 526,113) and the use of survey weights provide robust evidence that the green transition is positively and significantly, albeit modestly, associated with the likelihood of formal-sector employment, consistent with the main findings of the international literature on the green transition and labor markets. These findings should nonetheless be read as associational rather than causal. The one-year lag between the index (2023) and labor outcomes (2024) establishes temporal precedence but does not rule out reverse causality at the provincial level. For instance, provinces with more formal employment may also attract more green investment, nor does it rule out omitted province-level confounding. Panel data spanning multiple years would be needed to more credibly identify the direction of this relationship, flagged as a priority for future research. In addition, because the number of provincial clusters (38) sits near the lower bound at which cluster-robust standard errors are considered reliable (Colin Cameron and Miller, 2015), inference on the green transition coefficient should be interpreted with some caution. Finally, Indonesia's labor market structure with high agricultural informality, strong regional fiscal disparities, and a decentralized government structure may limit direct generalizability to developing economies with different structural profiles. The findings are best read as illustrative of a broader class of labor-surplus developing economies with large informal sectors and decentralized green-investment financing.

5. Conclusion and Policy Implications

5.1 Conclusion

The logistic regression results in Table 4 support the proposed hypothesis. The green transition variable is positively and statistically significantly associated with the probability of being employed in the formal sector after controlling for age, gender, marital status, education level, sector, and occupation of the businesses in which respondents are working, the place of residence, and region, as well as macroeconomic growth rates and the labor participation rate. The odds ratio adjusted for those variables is 1.01 (95% CI: 1.01–1.02; $p<0.01$). It means that a 1-unit increase in the green transition index increases the chances of having formal-sector employment rather than informal employment by 1%.

This result also contradicts the descriptive statistics in Table 3, which found that the green transition had a higher average among informal employees. When controlling for age, the main potential confounder, in the logistic regression model, the correlation reversed from negative to positive. Thus, the association between green transition and formal employment becomes apparent only after multivariable adjustment; differences in age composition between formal and informal workers may contribute to this change, alongside the simultaneous adjustment for education, occupation, and sector. In terms of implications, the study confirms that promoting green transition can serve as one strategy to increase job formalization, although its effect is limited compared with structural factors such as higher education (aOR = 2.72), industry sector (aOR = 7.84), or white-collar jobs (aOR = 11.98).

5.2 Policy implications

Based on the results, policies promoting formalization in the labor market should not focus solely on green activity factors. Informality is no longer seen as an issue that hinders the pace of the green transition. However, the government can consider informality a strength by actively participating in more inclusive development. The following policies can be considered to address the issues of labor surplus and high informality, especially in developing countries:

- The green transition does not automatically formalize informal workers. Governments should pair green investment incentives (e.g., tax breaks for solar panel installers) with formalization requirements, such as simplified business registration and access to social protection for green-sector micro-enterprises.

- Interventions should focus on enhancing educational access, strengthening labor regulations, and offering training programs. Improving the quality of human capital aims to further align the labor force with the demands of the green transition. In implementation, insights about the green transition should begin to be incorporated into education curricula, training, and formal regulation.

- Because the formalization gap associated with occupation and industry sector is far larger than the green transition effect, priority should go to vocational and technical training pipelines that move workers into industrial-sector formal jobs, and to simplified registration targeted at agriculture-adjacent micro-enterprises, rather than treating green incentives as a primary formalization lever. Green investment incentives are best treated as a complementary instrument, paired with formalization requirements such as simplified business registration and social-protection access for green-sector micro-enterprises.

Data availability statement
The study uses fully anonymized datasets from the August 2024 SAKERNAS, provided by BPS under data-sharing agreements (Letter No. 46/LADU/0000/01/2025). There was no direct contact with individuals or access to identifiable information.

Funding
The author received no funding for the present research

AI Disclosure Statement
All stages, including concept development, manuscript preparation, estimation, and analysis, were performed by human researchers. Trinka AI was used solely for language refinement and grammar checking after the initial draft was completed.

Conflict of Interest
The author declares no conflict of interest.

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Appendix

A.Green Transition PCA Index

Table A.1 Feasibility test of factor analysis

Determinant	Value
Kaiser-Meyer-Olkin (KMO)	0.639
Bartlett's test of sphericity	$\chi^2 = 190.033$; $p = 0.000$

Table A.2 Eigenvalues and Variance Proportion

Component	Eigenvalue	Difference	Proportion (%)	Cumulative (%)
Component 1	3.51716	2.54179	0.7034	0.7034
Component 2	0.975367	0.62704	0.1951	0.8985
Component 3	0.348327	0.200311	0.0697	0.9682
Component 4	0.148016	0.136888	0.0296	0.9978
Component 5	0.011128	.	0.0022	1

Table A.3 Component Loadings

Variable	Component 1	Component 2	Component 3	Component 4	Component 5
IS	-0.2126	0.9035	0.3499	0.1179	-0.0461
RO	0.4933	0.0498	0.4057	-0.7537	-0.1469
IC	0.5051	-0.0745	0.4302	0.4402	0.6004
GI	0.5225	0.052	-0.0634	0.4514	-0.7187
ER	0.4281	0.4158	-0.7238	-0.1433	0.3151

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