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Impact of Digital Technology Access and Structural Factors on Women's Labor Force Participation in Indonesia

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Abstract

This study examines the effects of digital technology access, gender equality, regional economic development, and minimum wage policy on women's labor force participation in Indonesia. Using an annual provincial panel data set for the period 2015-2024 (t = 10), yielding 340 annual observations, the analysis applies a dynamic panel regression based on an Error Correction Model to distinguish long-run relationships from short-run dynamics. The results confirm a long-run relationship between digitalization, the gender development index, gross regional domestic product per capita, the provincial minimum wage, and women's labor force participation. In the long run, the gender development index, gross regional domestic product per capita, and the provincial minimum wage have positive and statistically significant effects on women's participation, while digitalization has a positive but not yet significant effect. In the short run, changes in digitalization, the gender development index, and gross regional domestic product per capita positively and significantly affect changes in women's labor force participation, whereas changes in the provincial minimum wage are not significant. These findings suggest that digitalization mainly acts as a short-run opportunity trigger, while progress in gender equality, rising regional prosperity, and an adequate minimum wage function as key structural determinants of stronger women's labor force participation in the digital economy.

Keywords: Digitalization, Women's Labor Force Participation, GDRP per Capita, Provincial Minimum Wage, Error Correction Model

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INTRODUCTION

The transformation of the global economic structure marked by the spread of digitalization has shifted modes of work, patterns of production, and forms of employment relationships, including for women. The transition toward a knowledge-based and digitally driven service economy has generated new types of jobs such as platform-based work, online freelancing, remote working, and microenterprises built on social media, which are relatively more flexible with respect to spatial and temporal constraints.

Access to digital technologies such as the internet, computers, and communication devices has become a crucial precondition for taking advantage of these opportunities. Through digital technology, women gain broader access to information on job vacancies, online training and skills upgrading programs, as well as product and service markets that extend beyond the geographical boundaries of their place of residence.

In Indonesia, the acceleration of digitalization is reflected, among other things, in the rapid increase in household internet penetration over the past few years, which has surpassed 70 percent, thereby theoretically providing the basic infrastructure for expanding women's labor force participation.

However, this potential is confronted with persistent structural barriers, such as unequal division of domestic labor, limited physical mobility, conservative gender norms, and discrimination in formal labor markets, so that the opportunities created by digitalization have not yet been fully translated into higher female labor force participation.

From the perspective of Human Capital Theory, education, skills, and work experience are viewed as forms of investment that enhance productivity and increase an individual's chances of entering and remaining in the labor market (Becker, 1993). In the context of the digital economy, the ability to access and use technology, from internet utilization, mastery of computers and digital devices, to digital literacy encompassing the ability to search for, process, and critically use information, can be regarded as a form of "modern human capital" that complements formal education.

This digital human capital enables women to search for job information more efficiently, participate in training and skills enhancement without leaving their homes, build professional networks online, and access platform-based and remote jobs that are relatively more compatible with time constraints arising from domestic responsibilities.

A number of studies in developing countries show that women's use of digital technologies is positively correlated with their participation in the labor market, particularly through the expansion of flexible and remote work opportunities that can be negotiated alongside domestic roles (Zhao & Zhang, 2023; Kim et al., 2022; Prasetyo & Sari, 2024).

These findings strengthen the hypothesis that expanding digital access can increase women's chances of entering and remaining in the labor market, although the magnitude of the benefits depends heavily on the quality of digital literacy and the local socio-economic context.

Gender inequality theory emphasizes that women's decisions to work are influenced not only by individual preferences but also by the structure of opportunities and the constraints they face in education, health, and the economy. The Gender Development Index (GDI) provides a concise measure representing the degree of

equality in outcomes between men and women in these dimensions within a given area. A higher GDI indicates a smaller gap in achievements between men and women, which implicitly reflects lower structural barriers for women to participate in productive activities outside the home.

Empirical evidence shows that improvements in gender equality through expanded access to education, better reproductive health, and strengthened economic opportunities are consistently associated with higher female labor force participation, both by enhancing women's ability to compete in the labor market and by shifting social norms surrounding women's roles (Priebe & Rudolf, 2020; Lee & Chen, 2023). Thus, the GDI can be regarded as a key indicator that not only reflects gender development outcomes but also serves as a proxy for the magnitude of structural barriers women face in entering the labor market across regions.

Within the framework of regional economic development, growth in Gross Regional Domestic Product (GRDP) per capita reflects an increase in a region's economic capacity and the expansion of its production base, which potentially creates more jobs. As the economy grows, the structure of economic activity tends to shift from the primary sector toward industry and services, which in many cases absorb relatively more female labor than traditional agriculture (Todaro & Smith, 2015).

Regions with higher per capita income generally have more diverse and dynamic labor markets, with the growth of modern services, social services, financial services, trade, and manufacturing industries that are more open to women's participation (Klasen & Pieters, 2020; Cameron et al., 2021; Zhang et al., 2023).

Economic growth may also alter household preferences regarding women's work decisions: when available job opportunities become more productive and offer attractive returns, the economic benefits of women's labor force participation can outweigh opportunity costs such as the loss of time for domestic work and childcare, thereby encouraging more women to enter the labor market.

From the perspective of incentive mechanisms, Efficiency Wage Theory posits that higher wage levels can serve as a driving force for individuals to enter and remain in the labor market (Akerlof & Yellen, 1986). In the Indonesian context, the Provincial Minimum Wage (UMP) is an important policy instrument that signals the minimum level of remuneration in the formal sector. Increases in the UMP have the potential to attract more women into formal employment because they offer more predictable, relatively stable income and greater capacity to cover opportunity costs associated with working outside the home, including childcare and transportation costs.

Several studies find that minimum wage policies can influence women's decisions to work, although the size and direction of the impact vary across provinces and depend on local labor market structures (AiPEG, 2017; Klasen & Pieters, 2015; Kim et al., 2021). On the one hand, higher minimum wages can strengthen incentives for women to enter the formal labor market; on the other hand, the impact on labor demand may differ across regions, resulting in heterogeneous net effects on female labor force participation.

This indicates that the UMP has the potential to become one of the pull factors for women's labor force participation, particularly among groups that place greater weight on

income security, social protection, and job stability.

Methodologically, the dynamics of the relationship between digitalization, gender equality, economic development, wage policies, and women's labor force participation are relevant not only at a single point in time but also along a longer trajectory. The Error Correction Model (ECM) framework provides the basis for analyzing situations in which economic variables form a stable long-run (cointegrating) relationship while at the same time experiencing short-run deviations due to various shocks.

In this approach, the long-run relationship between women's labor force participation and its determinants (access to digital technology, gender development, GRDP per capita, and the provincial minimum wage) is first estimated, and then the short-run adjustment dynamics are modeled through an error-correction component that captures how quickly the system returns to its long-run equilibrium after deviations occur (Engle & Granger, 1987; Pesaran, Shin, & Smith, 1999).

In this study, these variables are viewed as structural determinants of women's labor force participation that shape long-run patterns, while year-to-year changes arising from policy shifts, macroeconomic shocks, or technological changes, generate short-run fluctuations that are gradually corrected.

Recent studies employing ECM indicate that the relationships between digitalization, gender equality, and women's labor force participation tend to be stable in the long run, despite non-trivial short-run fluctuations (Zhang et al., 2023; Lee & Chen, 2022), making this framework highly relevant for analyzing the Indonesian context.

Although international literature has emphasized the importance of digitalization, gender equality, and economic growth for women's labor force participation, empirical evidence that is specifically tailored to the Indonesian context remains relatively limited and often yields mixed results.

Most previous studies have focused more on "classical" determinants of female labor force participation, such as education, marital status, number of children, and household characteristics, while the digitalization dimension is often only partially addressed, uses narrow indicators, or is confined to specific case studies.

At the same time, disparities in digital access between men and women across provinces still indicate the presence of a gender digital divide that may generate new forms of inequality in access to information, networks, and job opportunities mediated by technology (UN Women, 2022).

Interactions between digitalization, gender equality, GRDP per capita, and the UMP have also rarely been analyzed in an integrated, dynamic framework capable of distinguishing between short-run and long-run effects on women's labor force participation.

Given these conditions, at least two research gaps emerge. First, there is a shortage of studies that explicitly evaluate the impact of digitalization on women's labor force participation in Indonesia using provincial panel data over a sufficiently long period, even though there is substantial interprovincial variation in digital access, gender development, and economic capacity.

Second, dynamic panel regression approaches that can disentangle long-run and short-run relationships such as panel ECM, have

not been widely employed to analyze how women's labor force participation adjusts in response to gradual changes in digitalization, gender equality, economic growth, and the minimum wage. These methodological limitations risk obscuring the distinction between structural long-run factors and short-run shocks in empirical interpretation.

This study is formulated to address three main research questions: (1) how does access to digital technology affect women's labor force participation in Indonesia; (2) what roles do the Gender Development Index, GRDP per capita, and the Provincial Minimum Wage play in explaining interprovincial variation in women's labor force participation; and (3) does a long-run relationship exist between digitalization and women's labor force participation, and how does the short-run adjustment mechanism operate?

To answer these questions, the study uses provincial panel data for Indonesia and applies a dynamic panel regression approach with an Error Correction Model (ECM), which allows for the simultaneous identification of long-run relationships and short-run adjustment dynamics.

Academically, this study contributes by incorporating the digitalization dimension as a form of modern human capital into the analysis of women's labor economics in Indonesia, while also integrating gender equality, regional economic development, and minimum wage policy into a coherent empirical framework.

Methodologically, the use of panel ECM offers advantages over static panel models because it can distinguish long-run structural effects from short-run transient fluctuations. Practically, the findings of this study are expected to provide inputs for central and local governments, as well as development organizations, in designing digital access expansion policies that are responsive to women's needs, strengthening gender equality agendas, promoting gender-inclusive regional economic development, and formulating minimum wage policies that support stronger women's labor force participation in the digital economy era.

Building on this theoretical and empirical background, the present study formulates the following hypotheses. First, higher access to digital technology is expected to be associated with higher women's labor force participation, both in the short run and the long run (H1).

Second, greater gender development, as reflected in a higher Gender Development Index (GDI), is expected to have a positive effect on women's labor force participation (H2). Third, higher Gross Regional Domestic Product (GRDP) per capita is expected to increase women's labor force participation by expanding the demand for female labour in more diversified and modern sectors (H3).

Fourth, higher Provincial Minimum Wages (UMP) are expected to exert a positive effect on women's labor force participation by strengthening the incentives to enter formal employment (H4). Finally, access to digital technology, gender development, GRDP per capita, and the provincial minimum wage are expected to form a stable long-run cointegrating relationship with women's labor force participation in Indonesia (H5).

RESEARCH METHODS

This study employs a quantitative research design with a panel data approach. It uses a dynamic regression framework, specifically the Error Correction Model (ECM), to analyze the relationship between digitalization, gender

development, economic growth, and minimum wages and the level of women's labor force participation in Indonesia. The ECM design is chosen because of its ability to identify long-run relationships among these variables, as well as to capture short-run fluctuations that may occur (Pesaran, Shin, & Smith, 1999).

The data used in this study are secondary panel data comprising relevant macroeconomic and social variables. The data are obtained from Statistics Indonesia (BPS) and other reliable sources, covering annual observations for the period 2015-2024. The unit of analysis is the province in Indonesia, yielding a balanced panel of 34 provinces based on the pre-division (pre-2022) administrative boundaries.

We intentionally use 34 provinces rather than the current 38 to maintain temporal consistency and data completeness, because official statistics for the newly established provinces are not yet available for the years prior to 2023.

These new provinces result from the division of Papua into Papua, South Papua, Central Papua, and Highland Papua, and from the division of West Papua into West Papua and Southwest Papua. The analysis focuses on variables related to digitalization, gender development, the economy, and minimum wages that influence women's labor force participation. Table 1 presents the operational definitions, indicators, and measurements of the variables used in this study.

This study employs a panel-data Error Correction Model (ECM), which enables the analysis of both long-run and short-run interactions between the explanatory variables and the dependent variable—women's labor force participation. The ECM approach is selected because economic variables typically do not move independently in a single period; instead, they tend to form a long-run equilibrium relationship, with short-run fluctuations occurring before convergence back to equilibrium (Engle & Granger, 1987).

All variables are transformed into natural logarithms, allowing the coefficients to be interpreted as elasticities. The estimation incorporates cross-section fixed effects to control for unobserved provincial differences that remain constant over time. In general, the ECM used in this study can be expressed in the following form:

$$\Delta TPAK_{it} = \alpha + \beta_1 \Delta Digitalization_{it} + \beta_2 \Delta IPG_{it} + \beta_3 \Delta PDRB_{it} + \beta_4 \Delta UMP_{it} + \gamma\ (TPAK_{it-1} - \alpha_0 - \beta_1 Digitalization_{it-1} - \beta_2 IPG_{it-1} - \beta_3 PDRB_{it-1} - \beta_4 UMP_{it-1}) + \varepsilon_{it}$$

This equation shows that year-to-year changes in women's labor force participation are driven by short-run variations in digital access, gender development, regional income, and minimum wage levels. The error-correction component captures how adjustments are made when women's labor force participation deviates from its long-run equilibrium. The speed of this adjustment is reflected in the parameter γ.

The data analysis follows a panel ECM framework. The first step involves applying the Augmented Dickey–Fuller (ADF) unit root test to ensure that the variables become stationary at the first difference. This step is essential to avoid the risk of spurious regression that may occur if non-stationary series are used. After verifying integration at order one, a Pedroni cointegration test is conducted to assess whether a stable long-run relationship exists among the variables included in the model, which would justify the application of ECM.

If the results confirm that cointegration exists, the ECM framework is subsequently applied to estimate the variables' long-run coefficients and short-run adjustments. Through this approach, the study is able to examine the long-term influence of digitalization, gender development, regional economic performance, and minimum wage policies on women's labor force participation, while also capturing how short-term deviations from the long-run equilibrium are gradually corrected.

Table 1. Operational Definitions and Measurement of Research Variables

Variable	Operational Definition	Indicator	Measurement
Women's Labor Force Participation Rate (TPAK)	The percentage of women who are working or actively seeking work out of the total female working-age population in a given province.	Proportion of women who are working or seeking work	Ratio of the number of women who are working/seeking work to the number of women of working age (BPS, 2023).
Access to Digital Technology (Digitalization)	The percentage of households that have access to the internet and computers in a given province.	Proportion of households with access to the internet and computers	Percentage of households with internet access (SUSENAS).
Gender Development Index (GDI / IPG)	An index that measures gender equality in terms of education, health, and the economy in a given province.	Improvements in gender equality in the economy, education, and health	GDI value calculated based on BPS data.
GRDP per Capita (PDRB)	Gross Regional Domestic Product per capita, reflecting the average income level per individual in a given province.	Average income per individual	GRDP per capita value (BPS).
Provincial Minimum Wage (UMP)	The minimum wage set by the provincial government for formal employment in the province.	Magnitude of the provincial minimum wage	UMP value by province (BPS).

Source: Data processed, 2025

In addition, a series of residual diagnostic tests is performed to ensure that the regression model satisfies standard econometric assumptions. Overall, the ECM provides a comprehensive tool for analyzing the dynamic interactions that shape women's labor force

participation across Indonesian provinces. Conceptually, the long-run relationship between women's labor force participation and its determinants can be written in the following cointegration equation:

$$TPAK_{it} = \alpha_0 + \beta_1 Digitalization_{it} + \beta_2 IPG_{it} + \beta_3 PDRB_{it} + \beta_4 UMP_{it} + u_{it}$$

where $TPAK_{it}$ is the women's labor force participation rate in province i and year t; $Digitalization_{it}$ is access to digital technology; IPG_{it} is the Gender Development Index; $PDRB_{it}$ is GRDP per capita; UMP_{it} is the Provincial Minimum Wage; α_0 is the long-run constant; β_1, β_2, β_3, β_4 are the long-run coefficients representing the elasticity of TPAK with respect to each explanatory variable; and u_{it} is the long-run error term (cointegration residual). Based on this long-run relationship, the ECM used for the estimation can be expressed as:

$$\Delta TPAK_{it} = \alpha + \beta_1 \Delta Digitalization_{it} + \beta_2 \Delta IPG_{it} + \beta_3 \Delta PDRB_{it} + \beta_4 \Delta UMP_{it} + \gamma(TPAK_{(it-1)} - \alpha_0 - \beta_1 Digitalization_{(it-1)} - \beta_2 IPG_{(it-1)} - \beta_3 PDRB_{(it-1)} - \beta_4 UMP_{(it-1)}) + \varepsilon_{it}$$

The equation above shows that changes in women's labor force participation, ΔTPAK_{it}, in a given province and year are driven by two main components. First, the short-run component, represented by contemporaneous changes Δ in access to digital technology, GDI, GRDP per capita, and UMP. The coefficients β_1, β_2, β_3, and β_4 in this part capture the short-run effects of each variable on changes in women's labor force participation.

Second, the error-correction component, represented by the term in parentheses (·), which is the deviation of women's labor force participation in the previous year from its long-run equilibrium relationship with access to digital technology, GDI, GRDP per capita, and UMP. This term is commonly referred to as the error correction term (ECT), and the coefficient γ measures the speed of adjustment back toward the long-run equilibrium.

Theoretically, γ is expected to be negative, meaning that when women's labor force participation is above (or below) its long-run equilibrium level, there will be a downward (or upward) adjustment in the subsequent period to correct this deviation.

The analytical technique employed is panel data analysis with an ECM approach. Before constructing the ECM, the first step is to perform stationarity tests using the Augmented Dickey–Fuller (ADF) test for each variable. This test aims to ensure that the variables used are not non-stationary at levels and become stationary after first differencing (integrated of order one, I(1)). Stationarity is crucial to avoid the problem of spurious regression, which can mislead the interpretation of relationships among variables.

Once it has been established that all variables are I(1), a panel cointegration test is carried out using the Pedroni test to identify the existence of a stable long-run relationship between women's labor force participation and its explanatory variables.

This cointegration test examines whether a linear combination of these non-stationary variables yields stationary residuals. If the Pedroni test indicates the presence of cointegration, it can be statistically concluded that there is a consistent long-run relationship among the variables, thereby making the use of the ECM valid and appropriate. In the next stage, the ECM is estimated to obtain two types

of information simultaneously: (1) the long-run coefficients reflected in the cointegration equation (through the parameters β_1, β_2, β_3, β_4 in the long-run equilibrium equation), and (2) the short-run coefficients reflected in the differenced equation (through the parameters β_1, β_2, β_3, β_4 on the changes in the variables, as well as the coefficient γ as the error-correction parameter).

In this way, the study is able to distinguish the long-run structural effects of digitalization, gender development, economic growth, and minimum wages on women's labor force participation, while also describing how deviations from the long-run equilibrium are gradually corrected in the short run.

As a final step, a series of diagnostic tests on the model residuals is conducted to ensure that the basic assumptions of regression are satisfied and that the estimated parameters are unbiased and efficient. This sequence of procedures enables a more in-depth and reliable analysis of the dynamics of the relationships between digitalization, gender equality, economic development, wage policy, and women's labor force participation in Indonesia.

RESULTS AND DISCUSSION

Descriptive statistics (Table 2) show that the women's labor force participation rate (TPAK) has an average value of 4.28, with a range between 3.74 and 4.47 and a standard deviation of 0.22. This indicates that differences in women's labor force participation across provinces and over time in the sample are relatively moderate: not highly uniform, but also not extremely dispersed.

Access to digital technology (Digitalization) has an average of 4.18, with a maximum value of 4.59 and a minimum of 2.79, and a standard deviation of 0.34. Compared with TPAK, variation in the digitalization indicator is slightly larger, reflecting a fairly pronounced digital access gap between provinces with high levels of technology adoption and those where digital access remains relatively lagging.

Table 2. Descriptive Statistics of the Research Variables

Variable	Mean	Max.	Min.	Std. Dev.
TPAK	4.28	4.47	3.74	0.22
Digitalization	4.18	4.59	2.79	0.34
IPG	4.50	4.56	4.36	0.04
PDRB	10.50	12.21	9.31	0.55
UMP	14.67	15.44	13.72	0.28

Source: Data processed, 2025

The Gender Development Index (GDI/IPG) shows a relatively high average value of 4.50, with a very narrow range between 4.36 and 4.56 and a standard deviation of only 0.04. The small standard deviation indicates that the level of gender development across provinces during the observation period tends to be homogeneous, with relatively minor differences around the mean.

For GRDP per capita (PDRB), the average stands at 10.50, with a minimum of 9.31 and a maximum of 12.21, and a standard deviation of 0.55. This suggests a fairly large degree of interprovincial variation, consistent with the reality that regional economic capacity and prosperity levels in Indonesia are highly diverse.

Meanwhile, the Provincial Minimum Wage (UMP) has an average of 14.67, with values ranging from 13.72 to 15.44 and a standard deviation of 0.28. Variation in UMP across provinces is relatively more contained than that of GRDP, indicating that although minimum

wage levels differ across provinces, provincial wage policies still move within a relatively narrow band.

Overall, these descriptive data indicate that: (1) GDI/IPG is the most homogeneous variable; (2) GRDP is the variable with the highest degree of variation; and (3) digitalization and UMP lie between the two, thus providing sufficient empirical variation to test their effects on women's labor force participation within the econometric model employed in this study.

Table 3. Results of Panel Unit Root Tests

Variable	p-values		Description
	Level	1st difference	
TPAK	0.0696	0.0000	I(1)
Digitalization	0.6030	0.0003	I(1)
IPG	0.9835	0.0021	I(1)
PDRB	0.6033	0.0433	I(1)
UMP	0.3781	0.0001	I(1)

Source: Data processed, 2025

The panel unit root test using the Fisher-ADF procedure reported in Table 3 shows that all variables are non-stationary at levels but become stationary after first differencing, as indicated by p-values below 0.05 for the first-difference specifications. These results imply that each series is integrated of order one, I(1), and therefore exhibits stochastic trends that make standard regressions in levels potentially spurious.

At the same time, the absence of variables integrated of order two, I(2), satisfies a key precondition for applying panel cointegration techniques. In this context, the stationarity properties of the data meet the requirements for subsequent Pedroni cointegration tests and for the use of the panel Error Correction Model (ECM), which explicitly relies on variables that are I(1) but share a stable long-run equilibrium relationship.

Table 4. Result of Panel Cointegration Test

	Statistic	Prob.
Panel PP-Statistic	-31.03009	0.0000
Panel ADF-Statistic	-10.18963	0.0000
Group PP-Statistic	-37.01098	0.0000
Group ADF-Statistic	-10.68363	0.0000

Source: Data processed, 2025

The results of the panel cointegration test using the Pedroni method are presented in Table 4. The test produces four main statistics, all of which are significant: the panel PP-statistic, panel ADF-statistic, group PP-statistic, and group ADF-statistic, each with a p-value of 0.0000. This indicates rejection of the null hypothesis of no cointegration and confirms the existence of a long-run relationship among the variables in the provincial panel.

The model selection tests indicate that the cross-section fixed effects model across provinces is more appropriate than the pooled or random effects models. The Chow test (Redundant Fixed Effects) for the long-run model yields a p-value of 0.0000 for the Cross-section F statistic, leading to rejection of the null hypothesis that fixed effects are not required.

The Hausman test comparing the fixed and random effects models also produces a p-value of 0.0000 for the cross-section random specification, indicating that the random effects estimator is inconsistent and that the cross-section fixed effects model is the appropriate specification for estimation.

The long-run estimates of the relationship between women's labor force participation (Y)

and the explanatory variables Digitalization, GDI, GRDP per capita, and UMP are presented in Table 5. The results show that, in the long run, the level of digitalization is positively but insignificantly associated with women's labor force participation, implying that increased digital access cannot yet be said to convincingly drive higher female labor force participation.

Table 5. Long-Run Relationship of the Baseline Model

Variable	Coefficient	Prob.
C	48.92775	0.0000
Digitalization	0.040615	0.6094
IPG	7.293339	0.0000
PDRB	0.791738	0.0000
UMP	0.249019	0.0446

Source: Data processed, 2025

In contrast, the Gender Development Index (GDI), GRDP per capita, and the Provincial Minimum Wage (UMP) are found to have positive and statistically significant effects on women's labor force participation, indicating that improvements in gender equality, rising regional prosperity, and increases in the minimum wage tend to be accompanied by higher female participation in the formal labor market.

The constant term in the model represents the average baseline level of women's labor force participation when all explanatory variables are at their reference levels. The R-squared value of the long-run model is 0.5128, with a Prob(F-statistic) of 0.0000, indicating that, taken together, the explanatory variables have a statistically significant long-run effect on women's labor force participation.

The panel ECM estimates linking changes in women's labor force participation to changes in the explanatory variables and the error correction term (ECT(-1)) are presented in Table 6.

Table 6. Short-Run Relationship from the ECM

Variable	Coefficient	Prob.
C	-0.078427	0.0000
D(Digitalization)	0.619037	0.0000
D(IPG)	6.302294	0.0000
D(PDRB)	0.718750	0.0005
D(UMP)	0.128749	0.2907
ECT(-1)	-0.513858	0.0000
R-squared	0.318516	
Prob(F-statistic)	0.000000	

Source: Data processed, 2025

The short-run model results show that the negative and statistically significant constant term reflects a tendency for downward adjustment in changes in women's labor force participation when all explanatory variables remain unchanged. Year-on-year increases in digitalization significantly stimulate higher changes in women's labor force participation.

The accelerated improvement in the Gender Development Index (GDI/IPG) and increases in GRDP per capita have positive and significant effects on changes in women's labor force participation, indicating that, in the short run, progress in gender equality and income growth is accompanied by rising female participation in the labor market.

Meanwhile, changes in the Provincial Minimum Wage (UMP) are not found to have a significant effect on short-run changes in women's labor force participation. The negative and significant coefficient of ECT(-1) indicates the presence of an error-correction mechanism, whereby roughly half of the deviation of women's labor force participation from its long-

run equilibrium is corrected within one subsequent period.

The R-squared value of the ECM model is 0.3185 with a Prob(F-statistic) of 0.0000, indicating that, in the short run, changes in the explanatory variables jointly have a statistically significant effect on changes in women's labor force participation.

The heteroskedasticity test using the likelihood ratio yields a test statistic of 25.3862 with 34 degrees of freedom and a p-value of 0.8568. Since this value is greater than 0.05, the null hypothesis of homoskedasticity cannot be rejected; the ECM model therefore does not exhibit evidence of disruptive heteroskedasticity.

In the long run, digitalization has a positive but statistically insignificant coefficient with respect to women's labor force participation. The long-run elasticity of women's labor force participation with respect to digitalization is 0.04 and not statistically different from zero, whereas in the short run the elasticity reaches 0.62 and is highly significant.

This finding indicates that the expansion of digital technology access at the provincial level has not yet been fully translated into a structural rise in female labor force participation. Within the Human Capital Theory framework, this suggests that digital access alone is insufficient without complementary improvements in digital skills, appropriate job opportunities, and institutional support to reduce classic barriers such as time constraints, occupational segregation, and discriminatory hiring practices.

This pattern partly contrasts with evidence from China and other developing countries, where digital technology adoption is often found to exert a more persistent positive effect on women's labor market outcomes (Zhao & Zhang, 2023; Kim et al., 2022; Zhang et al., 2023). However, it is broadly consistent with Indonesian studies which show that digital use tends to benefit women who already possess adequate human capital and operate in sectors compatible with digital work, so that the aggregate impact may be uneven and context-dependent (Prasetyo & Sari, 2024).

In this study, the positive and significant short-run effect of changes in digitalization on changes in women's labor force participation indicates that the expansion of internet and computer access can trigger rapid responses, for example increased job search, entry into platform-based work, or engagement in online microenterprises.

However, these responses have not yet crystallized into a permanent structural increase at the long-run horizon. In other words, in this model digitalization appears to function more as a short-run "opportunity trigger" than as a stable long-run determinant. Accordingly, H1 is only partially supported: it is supported in the short run but not statistically supported in the long run.

The GDI (IPG) is found to have a positive and highly significant effect both in the long run and the short run. The long-run elasticity of women's labor force participation with respect to the GDI is about 7.29, while the short-run elasticity is around 6.30. These relatively large elasticities indicate that even modest improvements in gender development are associated with disproportionately higher women's participation in the labor market.

This finding is in line with Gender Inequality Theory, which posits that the fewer the structural barriers in education, health, and the economy, the greater the likelihood that women will enter and remain in the labor

market. Empirically, the result is consistent with studies showing that enhanced gender equality through better educational attainment, improved reproductive health, and stronger economic opportunities tends to raise female labor force participation by increasing women's productivity and shifting social norms surrounding women's roles (Priebe & Rudolf, 2020; Lee & Chen, 2022, 2023).

It also resonates with evidence on the gender digital divide in Asia, which highlights that women benefit more from digitalization when basic gender gaps in human development are reduced (UN Women, 2022). Thus, the theoretical expectation and the hypothesis regarding the GDI as a proxy for structural gender equality are strongly supported by these results, providing robust empirical support for H2.

GRDP per capita has a positive and significant effect both in the long run and the short run. The estimated elasticities, 0.79 in the long run and 0.72 in the short run, indicate that increases in regional income are systematically accompanied by higher women's labor force participation.

This is consistent with Regional Economic Development Theory, which states that an increase in regional economic capacity expands labor demand, particularly in modern services and manufacturing sectors that are relatively more open to female workers (Todaro & Smith, 2015).

The result echoes findings from cross-country and regional studies showing that economic growth and structural transformation from agriculture into industry and services are associated with higher female labor force participation, provided that new jobs are accessible to women (Klasen & Pieters, 2020; Cameron et al., 2021; Zhang et al., 2023). In the Indonesian context, this suggests that provinces with more dynamic and diversified economies tend to create employment opportunities in sectors such as trade, hospitality, finance, and social services that facilitate women's entry into the labor market. Hence, H3 is clearly supported by the empirical findings of this study.

In the long run, the Provincial Minimum Wage (UMP) has a positive and significant effect on women's labor force participation, with a long-run elasticity of around 0.25, while the short-run coefficient of changes in the UMP is positive but statistically insignificant. This pattern is in line with Efficiency Wage and Incentive Theory, which views wages as a signal of the attractiveness of formal employment and as compensation for opportunity costs, including childcare, domestic responsibilities, and commuting costs (Akerlof & Yellen, 1986).

The long-run result supports previous Indonesian evidence that higher minimum wages can, under certain conditions, encourage women to enter the formal labor market by making formal jobs more financially rewarding and more likely to provide social protection (AiPEG, 2017; Klasen & Pieters, 2015a; Kim et al., 2021).

At the same time, the absence of a significant short-run effect suggests that minimum wage changes do not immediately translate into annual adjustments in women's labor supply. This is consistent with earlier studies that highlight heterogeneous and sometimes delayed effects of minimum wage policies across provinces and sectors, depending on local labor demand conditions and firms' adjustment strategies.

In this study, the UMP appears to play a more structural role, influencing women's

participation through slower channels such as gradual formalization of employment, changes in household labor allocation, and shifts of workers from informal to formal jobs. Thus, H4 is partially supported: it is supported in the long run but not statistically supported in the short run.

The coefficient of the Error Correction Term, ECT(–1), is negative and significant at –0.513858, confirming the presence of an adjustment mechanism toward the long-run equilibrium. In interpretive terms, this value indicates that around 51 percent of the deviation from the long-run equilibrium in women's labor force participation in the previous period is corrected within one subsequent period.

This relatively strong speed of adjustment is consistent with the theoretical properties of Error Correction Models, in which variables that share a long-run cointegrating relationship tend to revert back to their equilibrium path after transitory shocks (Engle & Granger, 1987; Pesaran, Shin, & Smith, 1999).

It is also in line with recent ECM-based studies that document stable long-run relationships between gender equality, digitalization, and women's labor force participation, accompanied by non-trivial short-run fluctuations (Zhang et al., 2023; Lee & Chen, 2022). In the present context, it implies that when shocks occur to digitalization, the GDI, GRDP per capita, or the UMP, women's labor force participation in Indonesian provinces tends to return toward its long-run path with a relatively strong adjustment speed.

From a policy perspective, these empirical findings provide several concrete implications. First, the strong short-run elasticity of women's labor force participation with respect to digitalization (0.62) suggests that a 10 percent increase in household access to the internet and computers is associated, on average, with a 6.2 percent rise in women's labor force participation in the short run, holding other factors constant.

However, the absence of a significant long-run effect indicates that digital access needs to be embedded within broader strategies that raise women's digital skills and connect them to actual job opportunities. In practical terms, this implies that national and regional initiatives to expand digital infrastructure, as formulated in the RPJMN and RPJMD, should be complemented by targeted digital literacy and upskilling programs for women, especially in provinces where both digitalization and women's labor force participation are relatively low.

Collaboration with private actors, such as e-commerce platforms, digital service providers, and hospitality and tourism associations, can be used to design training modules that are directly linked to concrete income-generating opportunities, for example online micro-entrepreneurship, remote customer service, or digital content-based services.

Second, the large elasticities associated with the GDI underscore that improvements in gender development have substantial payoffs in terms of women's labor force participation. Provinces that succeed in reducing gender gaps in education, health, and economic resources can expect disproportionately higher gains in women's participation in the labor market.

This suggests that gender equality components within the RPJMN and RPJMD, such as investments in girls' secondary and tertiary education, reproductive health services, childcare facilities, and gender-responsive social protection, are not only social equity measures but also effective labor market policies.

Operationally, local governments can prioritize gender mainstreaming and gender-responsive budgeting in sectors that are closely linked to women's work decisions, including education, health, transportation, and care services.

Third, the positive and significant effects of GRDP per capita in both the long and short run indicate that strategies for regional economic development can be explicitly calibrated to be more gender-inclusive. In provinces with rapidly growing GRDP, policy instruments such as investment incentives, industrial zoning, and sectoral development programs can be directed toward sectors that are empirically more open to female workers, such as modern trade, hospitality, financial and business services, creative industries, and social services.

Collaboration with the private sector can take the form of targeted incentives or recognition schemes for firms that provide decent, flexible, and family-friendly jobs for women, including options for flexible hours or remote work that harness digital technologies.

Fourth, the finding that the UMP has a positive effect only in the long run implies that minimum wage policy can support women's labor force participation if it is designed as part of a broader package of labor market policies. Increases in the UMP that are aligned with productivity growth and accompanied by support for small and medium enterprises, including access to credit, technology upgrading, and management training, can strengthen the attractiveness of formal employment for women without unduly suppressing labor demand.

In addition, enforcing existing labor regulations related to maternity protection, childcare support, and non-discrimination can ensure that higher minimum wages translate into genuinely better-quality jobs for women rather than merely nominal wage increases.

Overall, the combination of a strong adjustment speed toward the long-run equilibrium and distinct short-run versus long-run effects across variables suggests that policy interventions should be sequenced and integrated.

Digitalization policies, gender equality programs, regional development strategies, and minimum wage setting need to be aligned so that short-run "opportunity triggers" created by digital access and economic growth can be transformed into sustained, structurally higher women's labor force participation through long-run improvements in gender development and wage structures.

CONCLUSION

Based on a provincial panel analysis for Indonesia over the period 2015-2025 using an Error Correction Model (ECM) approach, this study shows that there is a significant long-run relationship between digitalization, the Gender Development Index (GDI/IPG), GRDP per capita, the Provincial Minimum Wage (UMP), and women's labor force participation (TPAK).

This is confirmed by the Pedroni cointegration test results and by the negative and significant coefficient of the Error Correction Term (ECT), which indicates an adjustment speed of around 51 percent toward the long-run equilibrium.

In the long run, the GDI, GRDP per capita, and the UMP have positive and significant effects on women's labor force participation. This means that improvements in gender equality, regional economic prosperity, and minimum wage levels tend to be followed by structural increases in women's participation in

the labor market. In contrast, digitalization exhibits a positive but insignificant coefficient, suggesting that the expansion of digital technology access at the provincial level is not yet sufficiently strong to explain increases in women's labor force participation in the long run.

In the short run, the ECM results show that changes in digitalization, the GDI, and GRDP per capita have positive and significant effects on changes in women's labor force participation, whereas changes in the UMP have no significant effect. These findings indicate that the expansion of digital access, accelerated progress in gender equality, and regional economic growth can generate rapid responses in women's labor market participation, while the adjustment effects of the UMP tend to operate through longer-term structural channels.

Overall, the research hypotheses are supported in the following pattern: the effects of digitalization (H1) and the UMP (H4) on women's labor force participation are partially supported, that is they are strong at one horizon (short run or long run) but not statistically significant at the other, whereas the effects of the GDI (H2), GRDP per capita (H3), and the existence of a stable long-run relationship as formulated in H5 are strongly supported by the estimation results.

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