

# Digitalization and entrepreneurial dynamism in South Africa: Evidence from a seemingly unrelated regression approach

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## Keywords

*Digitalisation, Self-Employment, Unemployment, Seemingly Unrelated Regression (SUR), Foreign Direct Investment (FDI), Labour Market Dynamics.*

## Abstract

*This paper investigates the structural impact of digitalisation on South Africa's labour market, focusing on the interdependence between self-employment (as a proxy for entrepreneurship) and unemployment. Using annual data from 1996 to 2024, a Seemingly Unrelated Regression (SUR) framework is employed to jointly estimate the determinants of changes in both outcomes, thereby exploiting the significant cross-equation error correlation confirmed by a Breusch–Pagan test. The results reveal a disruptive dual effect of digitalisation. ICT penetration significantly reduces self-employment while simultaneously increasing unemployment in the short run, consistent with technology-induced displacement effects. The analysis also confirms that entrepreneurship in South Africa is largely necessity-driven, as rising unemployment leads to higher levels of self-employment, but this does not translate into job absorption. Trade openness has a weakly positive effect on self-employment, suggesting modest entrepreneurial opportunities from global integration. Strikingly, foreign direct investment (FDI) is positively and significantly associated with unemployment, implying that FDI may initially be directed toward capital-intensive sectors or involve restructuring processes that temporarily displace workers. These findings highlight critical policy implications. There is an urgent need for targeted digital skills training and reskilling, the establishment of a dual-track entrepreneurship support system that differentiates between necessity- and opportunity-driven ventures, and a strategic focus on attracting labour-intensive, inclusive FDI. Collectively, the results provide empirical evidence that digitalisation, if left unmanaged, may exacerbate short-run unemployment but, with the right policy mix, can be harnessed to drive inclusive and sustainable economic growth.*

## Introduction

Entrepreneurship plays a critical role in fostering inclusive economic growth, creating employment opportunities, and addressing income inequality in emerging economies such as South Africa (Herrington et al., 2021). As the global economy undergoes a digital transformation, digitalisation has emerged as a potential enabler of entrepreneurship by lowering entry barriers, reducing transaction costs, and broadening market access (Nambisan, 2017). In South Africa, where structural unemployment remains a persistent challenge and youth unemployment exceeds 45% (Statistics South Africa, 2024), the ability of digital tools and infrastructure to stimulate entrepreneurial activity is of increasing policy relevance.

Digitalisation, defined as the integration of digital technologies into economic and social processes, has transformed how businesses are conceived, launched, and scaled. From mobile money platforms and cloud-based services to e-commerce ecosystems and AI-driven customer engagement tools, the digital landscape has widened the scope for both necessity-driven and opportunity-driven entrepreneurs (Zhu et al., 2020). This transformation is particularly crucial in developing economies where traditional financial and infrastructural constraints limit formal business development. In South Africa, initiatives such as the Digital Economy Masterplan and the expansion of mobile broadband infrastructure signal the state's recognition of digital transformation as a lever for job creation and self-employment (Department of Communications and Digital Technologies, 2022).

Despite the growing policy emphasis on digital inclusion, empirical evidence on whether digitalisation has translated into higher levels of entrepreneurship in South Africa remains scarce. Most existing studies focus on firm-level case studies or qualitative assessments (Chigona & Licker, 2008; Mungai & Ogot, 2012),

with limited econometric analysis at the macroeconomic level. Moreover, the complex interrelation between digitalisation, self-employment, and unemployment necessitates a modelling framework that captures the interdependencies between these labour market outcomes.

This paper addresses this gap by examining whether digitalisation is associated with increased entrepreneurship in South Africa, using the number of self-employed individuals as a proxy. The analysis employs a Seemingly Unrelated Regression (SUR) model to simultaneously estimate the effect of digitalisation on entrepreneurship and unemployment, while controlling for macroeconomic and institutional factors such as GDP growth, FDI and education. By focusing on a system of equations rather than a single equation model, this approach allows for the efficient estimation of interrelated outcomes, acknowledging the dual role of digitalisation in job creation and displacement.

The study contributes to both the theoretical and policy discourse on digital transformation in emerging economies by offering empirical insights into the structural drivers of entrepreneurship in the digital era.

### **Theoretical literature review**

Entrepreneurship, a multifaceted concept, has evolved significantly across various theoretical perspectives. Understanding these foundational theories is crucial for examining how digitalisation might influence entrepreneurial outcomes, especially in dynamic emerging economies like South Africa. One prominent perspective, championed by Schumpeter (1934), defines entrepreneurs as agents of "creative destruction" who introduce novel products, processes, and markets. From this viewpoint, digitalisation acts as a powerful enabler, providing innovative tools and platforms such as fintech, e-commerce, and mobile applications that significantly reduce the cost and complexity associated with launching new ventures. Here, digital infrastructure serves as a catalyst for innovation-led entrepreneurship, fostering differentiation and market disruption.

Knight (1921), along with Foss and Klein (2012), highlight the entrepreneur's critical role in making decisions under uncertainty, particularly regarding resource deployment and forecasting future market conditions. In the rapidly evolving digital economy, where technological shifts heighten uncertainty, sound entrepreneurial judgement becomes paramount in selecting appropriate platforms, technologies, and target markets. This perspective complements the Theory of the Firm by positioning the entrepreneur as the central decision-maker who allocates capital even in the absence of complete information. Further elaborating on Coase's theory of the firm, Foss, Klein, and colleagues (2005; 2012) argue that entrepreneurial judgement is fundamental to a firm's existence and its boundaries. In digital contexts, entrepreneurs can choose between integrating functions, like in-house digital development, or leveraging decentralised, platform-based models such as Shopify or WhatsApp Business. The availability of digital tools directly influences these strategic boundary decisions, consequently reshaping the very nature of the firm in response to evolving cost structures and market access.

Kirzner (1973), representing the Austrian perspective, views entrepreneurship as the innate ability to identify previously unnoticed opportunities. In the digital age, these opportunities are often embedded within algorithmic trends, vast datasets, or shifting online consumer behaviors. Digital tools, including Google Trends, e-commerce analytics, and social media sentiment analysis, significantly amplify the scope for opportunity discovery by making information more accessible and actionable.

Building on psychological and cultural theories, some scholars, like Sarasvathy (2001), propose that entrepreneurship is rooted in imagination—the capacity to envision new realities, products, or services. Digitalisation significantly enhances this creative capacity by offering novel modes of expression, such as digital art, app design, and virtual marketplaces. For instance, in South Africa's informal sector, young entrepreneurs are leveraging platforms like TikTok, Instagram, and WhatsApp not merely as communication tools, but as dynamic and creative business platforms.

From a Penrose (1959) viewpoint, entrepreneurship is conceptualized as the effective organisation and management of resources. Digital technologies strongly support this managerial role by enhancing coordination, automating routine tasks, and facilitating lean operations. Tools like inventory management apps, cloud accounting software, and digital HR platforms empower small businesses to operate efficiently, even with limited staff and capital.

Finally, some perspectives frame entrepreneurship as the exercise of charismatic leadership and personal influence in mobilising people and resources, as highlighted by Weber (1947) and Burns (1978). Digital platforms, including YouTube, LinkedIn, and livestreaming applications, provide powerful channels through which entrepreneurs can build personal brands and mobilise social capital. In contexts where formal institutions may be weaker, such "digital charisma" becomes a potent resource for gaining legitimacy and achieving traction.

### Empirical literature review

To fully grasp the intricate relationship between digitalisation and entrepreneurship, it is essential to review existing empirical evidence from various global contexts, considering their diverse economic and digital maturity levels. This section provides a systematic overview of selected studies across six continents, highlighting their methodological approaches, the variables employed, and their key findings. This review aims to pinpoint existing research gaps that the present study seeks to address, particularly concerning South Africa and the application of system estimation techniques.

In Africa, research by Asongu and Nwachukwu (2018), utilising the Generalized Method of Moments (GMM) across 49 African countries from 2000 to 2012, explored whether ICT penetration fostered inclusive human development. They found a positive association between proxies for digitalisation, such as mobile phone subscriptions and internet penetration, and entrepreneurship-related development indicators. However, a limitation of their work is the use of a broad human development index rather than direct entrepreneurial metrics like self-employment, and the pan-African aggregation may obscure unique country-specific dynamics, such as South Africa's distinct digital-financial ecosystem. Conversely, Ndou et al. (2021) employed a qualitative approach with semi-structured interviews and thematic analysis to study digital entrepreneurship in Egypt, revealing that mobile payment systems and social media significantly supported informal business start-ups. While offering rich insights, this qualitative study lacks generalisability and does not establish causal links between digital infrastructure and entrepreneurial activity.

In North America, Chen et al. (2019) analysed data from the U.S. Panel Study of Entrepreneurial Dynamics to examine the impact of digital tools (e.g., cloud software, digital ads) on firm survival. Using probit and logit models, they found that early adoption of digital tools significantly improved start-up survival rates. While micro-level data allows for precise analysis of firm behaviour, it limits macroeconomic interpretation, and their reliance on self-reported digital adoption raises measurement reliability concerns. Forman and Goldfarb (2016), using a difference-in-differences approach, assessed broadband's effects on entrepreneurial density across U.S. counties, finding that broadband access increased new business formation, particularly in low-density rural areas. Although this study robustly addresses causality through its quasi-experimental design, it assumes broadband availability equates to usage, which might overstate effects in digitally excluded communities.

Moving to South America, Soto-Acosta et al. (2020) investigated SMEs in Colombia and Brazil using partial least squares structural equation modelling (PLS-SEM). Their findings indicated that digital orientation positively influences innovation, which, in turn, boosts entrepreneurial performance. A constraint of this study is its focus on formally registered SMEs, thereby excluding informal entrepreneurship, which is prevalent in many Latin American economies.

In Asia, Li et al. (2020) examined the effect of mobile payments on entrepreneurship in rural China using a two-stage least squares (2SLS) model with county-level panel data. Their study found that mobile payment platforms increased self-employment by improving market access and reducing transaction costs. While effectively addressing endogeneity and using direct measures of entrepreneurship, the results are context-specific and may not translate to economies with more complex labour markets or greater digital divides. Similarly, Mitra and Abubakar (2023) analysed the digital economy's effect on start-up activity in India using panel vector autoregression (PVAR), discovering that short-run digital shocks produced long-run effects on entrepreneurial growth. While their dynamic model effectively captures lagged effects, the chosen proxies (e.g., website domain registrations) might not fully encompass broader entrepreneurial ecosystems.

In Europe, Elia, Margherita, and Passiante (2020) conducted a multi-country study using the European Digital Entrepreneurship Scoreboard, employing panel fixed-effects models to assess how digital

infrastructure influences early-stage entrepreneurial activity. While offering comprehensive data coverage and robust estimation, their focus on EU states with relatively high digital readiness limits relevance to less developed digital economies. Autio et al. (2018) analysed data from 28 European countries using multilevel regression, finding that digital platform usage (e.g., Airbnb, Uber) correlated positively with entrepreneurial intentions, particularly among youth. While the behavioural focus is important, intentions may not always translate into actual business creation, and the study might underestimate structural barriers like capital access or policy constraints.

Finally, in Australia and Oceania, Maritz and Donovan (2019) conducted a survey-based study in Australia, assessing digital transformation readiness among entrepreneurs. Using regression and factor analysis, they found that digital self-efficacy strongly predicts entrepreneurial resilience and adaptation. While innovative in linking digital skills to entrepreneurship, this study relies on perceptual data and does not assess broader economic outcomes such as job creation or GDP impact.

This systematic review reveals a need for studies that directly examine the macroeconomic impact of digitalisation on entrepreneurship in specific emerging economies, such as South Africa, while simultaneously accounting for interconnected labour market dynamics through system estimation techniques. The extensive review of global empirical literature reveals a general consensus that digitalisation exerts a positive influence on entrepreneurship. However, a critical gap in the existing body of research becomes apparent. Specifically, there is a notable scarcity of studies that concentrate on South Africa's macroeconomic data through time-series approaches. Furthermore, the majority of existing research implicitly treats digitalisation as an exogenous variable, failing to model its simultaneous effects on both self-employment (as a proxy for entrepreneurship) and unemployment. This overlooks the potential for an interconnected dynamic between these crucial labour market indicators within a digitally evolving economy.

To address this methodological void, the present paper proposes the application of a Seemingly Unrelated Regression (SUR) model. This approach offers a significant methodological innovation by enabling the simultaneous estimation of the interdependence between entrepreneurship and unemployment in the context of a digitally transforming economy. This capacity to model such intricate interdependencies is largely absent from the currently reviewed literature, thereby positioning this study to offer a more comprehensive and nuanced understanding of how digitalisation shapes labour market and entrepreneurship dynamics in South Africa.

### Theoretical Justification of the SUR Model

The Seemingly Unrelated Regression (SUR) model, developed by Zellner (1962), is a system of linear equations designed to estimate multiple regression equations that may have different dependent variables and possibly different sets of explanatory variables but whose error terms are contemporaneously correlated. This correlation across equations implies that information from one equation's disturbances can improve the efficiency of estimates in another – a property that ordinary least squares (OLS) does not exploit when equations are estimated separately.

In classical regression analysis, the Gauss-Markov theorem assumes that the error terms are independently and identically distributed (i.i.d.). However, in multi-equation systems where the dependent variables are conceptually or structurally related, this assumption often fails. SUR corrects for this by estimating the equations jointly and accounting for cross-equation error correlations.

The general form of an SUR system is as follows:

$$y_i = X_i\beta_i + \varepsilon_i, \text{ for } i = 1, 2, \dots, M \quad (1)$$

Where:

- $y_i$ :  $T \times 1$  vector of dependent variables for equation  $i$
- $X_i$ :  $T \times K_i$  matrix of regressors
- $\beta_i$ :  $K_i \times 1$  vector of parameters
- $\varepsilon_i$ : Error term, assumed to follow a multivariate normal distribution across equations, i.e.,

$$\text{Cov}(\varepsilon_i, \varepsilon_j) = \Sigma_{ij} \neq 0 \text{ for some } i \neq j \quad (2)$$

The system can be expressed as:

$$Y = X\beta + \varepsilon \quad (3)$$

where  $\varepsilon \sim N(0, \Omega)$ , and  $\Omega$  is a block-diagonal variance-covariance matrix with off-diagonal elements capturing contemporaneous correlation.

The GLS (Generalized Least Squares) estimator under SUR is:

$$\widehat{\beta}_{SUR} = \left( \sum_{l=1}^M X_l' \Sigma^{-1} X_l \right)^{-1} \left( \sum_{l=1}^M X_l' \Sigma^{-1} y_l \right) \quad (4)$$

There are several theoretical reasons to prefer SUR in this paper. Entrepreneurship and unemployment are interrelated labour market outcomes influenced by overlapping factors such as macroeconomic shocks, digitalisation trends, or institutional quality. Estimating them separately risks omitting useful information from their joint distribution. The application of a Seemingly Unrelated Regression (SUR) model offers several distinct advantages for this study, particularly in the context of examining the interplay between digitalisation, entrepreneurship, and unemployment in an emerging economy.

Firstly, SUR provides efficiency gains over Ordinary Least Squares (OLS). When the error terms across different equations are correlated, SUR yields more efficient and unbiased estimators compared to separate OLS estimations. Given that digitalisation is likely to influence both self-employment and unemployment in an interdependent manner, the SUR model is uniquely positioned to capture these simultaneous effects more effectively than individual single-equation regressions.

Secondly, SUR is particularly adept at handling partial endogeneity and policy interaction. In emerging economies, public policies related to digitalisation, employment, and entrepreneurship are frequently implemented in a coordinated fashion. Consequently, exogenous shocks or policy interventions in one domain can contemporaneously impact others. SUR models are designed to account for this interconnected policy structure without necessitating a full-blown simultaneous equation model, thereby offering a more nuanced understanding of policy effectiveness.

Thirdly, SUR presents a robust alternative to traditional multivariate regression. Unlike multivariate regression, which assumes that all dependent variables are part of a single system sharing a common set of predictors, SUR allows each dependent variable to have a distinct set of predictors while still estimating them jointly. This characteristic is particularly advantageous for this study, as the determinants of entrepreneurship and unemployment, while overlapping, are not identical, enabling a more precise specification of each relationship.

Finally, the use of SUR is supported by strong precedent in development economics. This methodology has been widely applied in macro-development literature, demonstrating its utility and reliability in various complex economic analyses. Notable applications include public finance (e.g., modelling tax revenue and expenditure equations), labour markets (e.g., analysing employment and wage systems), and comprehensive policy analysis (e.g., jointly estimating education and health outcomes). This established track record reinforces the suitability of the SUR model for investigating the intricate relationships under consideration in this research.

## Model Specification

To capture the joint dynamics between self-employment and unemployment, we specify a system of two equations estimated using the Seemingly Unrelated Regressions (SUR) approach. Both equations include the same set of explanatory variables, with the key difference being the dependent variable.

### 1. Entrepreneurship Equation (Self-Employment as Proxy)

$$SE_t = \alpha_1 + \beta_1 ICT_t + \beta_2 GDPG_t + \beta_3 HCI_t + \beta_4 UEMP_t + \beta_5 UrbanPop_t + \beta_6 FDI_t + \beta_7 TradeOpen_t + \varepsilon_{1t} \quad (5)$$

### 2. Unemployment Equation

$$UEMP_t = \alpha_2 + \beta_1 ICT_t + \beta_2 GDPG_t + \beta_3 HCI_t + \beta_4 SE_t + \beta_5 UrbanPop_t + \beta_6 FDI_t + \beta_7 TradeOpen_t + \varepsilon_{2t} \quad (6)$$

Where:

Table 1: Explanation of the variables

Symbol	Description
$SE_t$	Number of self-employed individuals (proxy for entrepreneurship)
$UEMP_t$	Unemployment rate
$ICT_t$	Digitalisation proxy (e.g., mobile broadband subscriptions per 100 people)
$GDPG_t$	Real GDP growth rate
$HCI_t$	Human Capital Index (proxy for education or literacy rate)
$UrbanPop_t$	Urban population share
$FDI_t$	Foreign direct investment (net inflows as % of GDP)
$TradeOpen_t$	Trade openness (exports + imports as % of GDP)
$\varepsilon_{1t}, \varepsilon_{2t}$	Equation-specific error terms

Equations (5) and (6) are estimated simultaneously using SUR to account for possible correlation of error terms across equations. This system specification allows us to jointly analyse the determinants of self-employment and unemployment while exploiting cross-equation information for efficiency gains.  $SE_t$  appears as an explanatory variable in Equation (6) to capture its influence on unemployment, and  $UEMP_t$  appears in Equation (5) to capture necessity entrepreneurship effects.

**The above equations are based on the following key assumption:**

$$\text{Cov}(\varepsilon_{1t}, \varepsilon_{2t}) \neq 0 \quad (7)$$

Indicating contemporaneous correlation between the disturbances of both equations, which justifies the use of the SUR model in this analysis.

### Presentation of the results

The analysis in this paper begins by testing the data series for stationarity. The method of stationarity test used is Dickey-Fuller Generalised Least Squares (DF-GLS).

### DF-GLS Stationarity test

Table 2 presents the results of the Dickey-Fuller Generalized Least Squares (DF-GLS) unit root tests for a set of economic and policy variables. The null hypothesis in each case is that the variable has a unit root (i.e., is non-stationary). A rejection of the null hypothesis (based on approximate p-values) indicates that the series is stationary. Where a variable was found to be non-stationary in levels, its first-differenced form was also tested and typically found to be stationary, confirming an integration order of I(1). These findings are useful for model selection in econometric analysis, such as SUR estimations.

Table 2: DF-GLS Stationarity Results

Variable	Model	Lags	Test Statistic	p-value
ICT	with constant and trend	including 0 lags of (1-L)ICT	-2.11439	0.418
d ICT	with constant and trend	including 0 lags of (1-L)d ICT	-5.83156	0.000 ***
GDP_Growth	with constant and trend	including 2 lags of (1-L)GDP_Growth	-2.13495	0.418
d GDP_Growth	with constant and trend	including 0 lags of (1-L)d GDP_Growth	-9.19102	0.000 ***
Unemployment	with constant and trend	including 0 lags of (1-L)Unemployment	-1.70235	0.665
d Unemployment	with constant and trend	including 0 lags of (1-L)d Unemployment	-5.52291	0.000 ***
Trade_Open	with constant and trend	including 0 lags of (1-L)Trade_Open	-3.40528	0.042 **
Urban_Pop	with constant and trend	including 0 lags of (1-L)Urban_Pop	-1.33968	0.876
d Urban_Pop	with constant and trend	including 0 lags of (1-L)d Urban_Pop	-5.69263	0.000 ***
FDI	with constant and trend	including 0 lags of (1-L)FDI	-5.38806	0.000 ***
Self_employed	with constant and trend	including 0 lags of (1-L)Self_employed	-1.78729	0.618
d Self_employed	with constant and trend	including 0 lags of (1-L)d Self_employed	-5.63015	0.000 ***
HCI	with constant and trend	including 0 lags of (1-L)HCI	-5.47956	0.000 ***

Note: p-values are followed by significance stars. \*\*\* = 1% significance, \*\* = 5% significance, \* = 10% significance.

The Augmented Dickey-Fuller (ADF-GLS) test was applied to all variables under the null hypothesis of a unit root. Each variable was tested with a model specification that included both a constant and a deterministic time trend. The lag structure was selected based on a modified AIC criterion. The objective was to establish whether the time series variables are stationary in levels or require differencing. The Augmented Dickey-Fuller (ADF-GLS) stationarity tests reveal that several key variables, including ICT, GDP growth, unemployment, urban population, and self-employment, are non-stationary in levels, as their test statistics do not reject the null hypothesis of a unit root at conventional significance levels. Conversely, trade openness is stationary at the 5% level, and both FDI and HCI are highly stationary at the 1% level. Once first differences are taken, all previously non-stationary variables become strongly stationary with p-values below 1%, confirming that they are integrated of order one, I(1). These findings imply that the dataset contains a mixture of I(0) and I(1) variables. In the context of the SUR framework, which estimates multiple equations jointly and exploits contemporaneous correlation of the error terms across equations, the presence of mixed orders of integration does not pose a problem as long as the equations are correctly specified. Using differenced series for the I(1) variables in the SUR specification helps to ensure that the regression results are not spurious, thereby improving the reliability and efficiency of the parameter estimates.

### Seemingly Unrelated Regression Results

The SUR results are presented in table 3 below:

Table 3: Seemingly Unrelated Regression Analysis

Variable	Eq. 1 Coeff.	Eq. 1 Std. Error	Eq. 1 t-Ratio	Eq. 1 p-Value	Eq. 2 Coeff.	Eq. 2 Std. Error	Eq. 2 t-Ratio	Eq. 2 p-Value
d ICT	-2.07591	0.22909	-9.062	7.02e-09 ***	0.69494	0.25881	2.685	0.0135 **
d GDP_Growth	-0.03219	0.05682	-0.567	0.5768	0.00321	0.03583	0.090	0.9295
HCI	-0.11915	0.16154	-0.738	0.4686	0.07083	0.10135	0.699	0.4920
d Unemployment	0.69603	0.28104	2.477	0.0214 **	—	—	—	—
d Self_employed	—	—	—	—	0.27343	0.11041	2.477	0.0214 **
d Urban_Pop	-2.74201	2.14231	-1.280	0.2139	-0.17750	1.38381	-0.128	0.8991
FDI	-0.23616	0.18210	-1.297	0.2081	0.36201	0.09405	3.849	0.0009 ***
Trade_Open	0.03315	0.01685	1.967	0.0619 *	-0.00600	0.01126	-0.533	0.5991

Equation 1 Summary: Mean dependent var = -0.80345 | S.D. dependent var = 5.73756 | Sum squared resid = 50.04353 | S.E. of regression = 1.31364

Equation 2 Summary: Mean dependent var = 0.50924 | S.D. dependent var = 1.07918 | Sum squared resid = 19.65922 | S.E. of regression = 0.82335

### Interpretation of SUR Results

The Seemingly Unrelated Regression (SUR) model was estimated jointly for two equations:

- **Equation 1:** Change in self-employment (d\_Self\_employed)
- **Equation 2:** Change in unemployment (d\_Unemployment)

This approach accounts for potential contemporaneous correlations between the error terms of the two equations, thereby improving the efficiency of coefficient estimates. The Breusch-Pagan test strongly rejects the null of zero cross-equation correlation ( $\chi^2 = 10.62$ ,  $p = 0.0011$ ), confirming that SUR is the appropriate estimation technique.

### Equation 1 - Determinants of Self-Employment

The analysis of Equation 1, which explores factors influencing changes in self-employment, reveals several significant relationships. The most influential factor is digitalisation, represented by the change in ICT penetration, which has a large, negative, and highly significant coefficient (-2.076, ). This result strongly indicates that the increasing adoption of ICT is associated with a reduction in self-employment, suggesting a disruptive effect where technology may be displacing informal or low-productivity entrepreneurial activity. Furthermore, the analysis provides robust support for the necessity entrepreneurship hypothesis, as a positive and significant relationship (0.696, ) exists between rising unemployment and an increase in individuals turning to self-employment as a survival mechanism. Trade openness also shows a positive, though weakly significant, effect on self-employment, suggesting that greater integration into international markets may marginally support entrepreneurial activity. Interestingly, other variables such as GDP growth, human capital investment (HCI), foreign direct investment (FDI), and urbanisation were found to be statistically insignificant, implying their short-run effects on changes in self-employment are weak or negligible in this context.

The analysis of Equation 2, which examines factors influencing changes in unemployment, reveals several significant relationships. The results indicate that digitalisation (ICT) has a positive and significant effect on unemployment (0.695, ), suggesting that as technology advances, it may cause short-term job displacement before new technology-driven jobs emerge. The model also shows a key finding which is a positive and significant relationship between changes in self-employment and changes in unemployment (0.273, ). This indicates that an increase in self-employment does not reduce unemployment; rather, they may occur simultaneously, reinforcing the "necessity entrepreneurship" hypothesis. Furthermore, FDI has a positive and highly significant effect on unemployment (0.362), an important insight that could suggest foreign investment is initially directed toward capital-intensive sectors with limited job creation or is associated with corporate restructuring that leads to temporary layoffs. Conversely, other variables such as GDP growth, human capital investment, urbanisation, and trade openness are statistically insignificant, suggesting they do not have a strong short-run influence on unemployment rates in this context.

### System Diagnostics

Table 4: Cross-equation VCV (variances on diagonal, correlations above)

1.7256	(-0.605)
-0.65462	0.67790

Log determinant: -0.299368

Breusch-Pagan test for diagonal covariance matrix: Chi-square(1) = 10.6234,  $p = 0.0011$

The provided diagnostics on the cross-equation residual diagnostics confirm the interconnected nature of your two regression models. The Cross-Equation Variance-Covariance Matrix (VCV) shows a higher residual variance for the self-employment equation (1.7256) than for the unemployment equation (0.6779), indicating more unexplained variability in the former. The off-diagonal element shows a significant negative correlation between the residuals (-0.605). This is a crucial finding, suggesting that unobserved shocks or factors that increase self-employment tend to decrease unemployment and vice versa. The Breusch-Pagan test with a highly significant p-value of 0.0011 robustly rejects the null hypothesis of no cross-equation correlation. This statistically validates the use of the Seemingly Unrelated Regression (SUR) model, confirming that it was the correct and more efficient approach than estimating the equations separately using Ordinary Least Squares (OLS), as SUR leverages this correlation to produce more precise coefficient estimates.

### Implications of the findings

These findings collectively highlight the significant and multifaceted implications of digitalisation for the modern labour market. The dual effect of ICT, simultaneously reducing self-employment and increasing unemployment, presents a clear structural challenge. This underscores the urgent need for a policy response focused on digital skills training and proactive labour market adjustments to ensure the benefits of technology are shared broadly. Furthermore, the results suggest that the quality of FDI matters; its link to rising unemployment indicates a need to attract investment that creates jobs and integrates into local value chains, rather than solely focusing on capital-intensive sectors. The clear dominance of necessity-driven entrepreneurship – where self-employment rises with unemployment – calls for targeted support programs designed to help these individuals build sustainable businesses. Finally, the mild but positive influence of trade openness on entrepreneurial activity signals that a focus on deeper trade facilitation could unlock further opportunities.

These results challenge some conventional assumptions and add nuance to existing debates about digitalization and labour markets. The dominant discourse often presents Information and Communication Technology (ICT) as a net positive for economies, driving growth and creating new, high-skilled jobs. However, these findings complicate this by showing a simultaneous negative impact on self-employment and a positive impact on unemployment. This aligns with a more critical theoretical perspective, such as Schumpeter's theory of creative destruction, where technological progress is inherently disruptive. It highlights a short-run transition period where old jobs and work models are destroyed before new ones are fully created (Aghion & Howitt, 1996), a nuance often lost in more optimistic narratives.

Traditional entrepreneurship theory often distinguishes between "opportunity-driven" entrepreneurship (pull factors) and "necessity-driven" entrepreneurship (push factors). While both are well-documented, these results provide powerful empirical evidence that the push-effect dominates in this specific context. The positive correlation between unemployment and self-employment directly challenges the idea that entrepreneurship is a primary solution to joblessness; instead, it's a symptom. This finding that self-employment also positively affects unemployment is particularly novel, as it pushes back on the assumption that more self-employment automatically reduces unemployment, suggesting that this growth is not creating new jobs but rather reflects a precarious form of work.

The prevailing theory on Foreign Direct Investment (FDI) posits that it boosts employment, especially in developing economies, by bringing capital, technology, and management expertise. The finding in this paper that FDI is positively and significantly linked to unemployment in the short run is a notable deviation from this. This finding supports a more critical theory, such as that FDI inflows are initially directed towards capital-intensive sectors or that multinational firms restructure local operations, leading to temporary layoffs (Smarzynska & Spatareanu, 2009). This finding challenges the simple cause-and-effect relationship often assumed in policy discussions and suggests a more complex dynamic at play.

### Policy Recommendations

The results underscore the urgent need for targeted digital skills training and reskilling to address the disruptive, short-run effect of ICT on unemployment. The findings suggest that digitalisation has increased unemployment in the short term, likely due to a mismatch between existing workforce skills and the requirements of new technology-driven jobs. Policymakers should therefore fund and promote comprehensive training programmes that go beyond basic computer literacy to include coding, data analytics, and digital marketing, thereby preparing workers for higher-value roles in the digital economy. Evidence from the literature shows that well-designed training programmes can mitigate the negative labour market effects of technological change (Acemoglu & Autor, 2011). In parallel, a dual-track entrepreneurship support system is required to distinguish between necessity-based and opportunity-driven entrepreneurship. For those pushed into self-employment by a lack of formal jobs, policy should provide basic business training, access to micro-loans, and support for formalisation to help build sustainable livelihoods. For entrepreneurs with scalable, high-growth ventures, mentorship, networking opportunities, and access to venture capital should be prioritised to maximise their potential for job creation. Finally, the results reveal that FDI has a positive short-run effect on unemployment, challenging the common assumption that all FDI is automatically beneficial for job creation. This highlights the importance of strategically attracting and managing FDI by prioritising investments that are labour-intensive, have strong domestic supply chain linkages, and include commitments to employee training. Governments should focus not merely on the quantity of FDI but on its quality and potential to generate employment spillovers (Borensztein et al., 1998).

### Conclusion

This study jointly estimated the determinants of self-employment and unemployment using a Seemingly Unrelated Regression (SUR) framework. The significant Breusch–Pagan statistic confirmed the presence of cross-equation error correlations, justifying the use of SUR to improve efficiency and exploit the information contained in the correlation structure. The results reveal several key insights. First, digitalisation has a dual and disruptive effect. It significantly reduces self-employment while simultaneously increasing unemployment in the short run. This finding highlights a structural adjustment process in which technology displaces informal or low-productivity entrepreneurial activity and creates transitional job losses before new opportunities emerge. Second, the positive association between unemployment and self-employment confirms that entrepreneurship in this context is largely necessity-driven. Individuals turn to self-employment as a survival strategy when formal jobs are scarce, which explains why higher levels of self-employment coexist with persistent unemployment. Third, trade openness exerts a weakly positive influence on self-employment, suggesting that deeper integration into global markets can stimulate entrepreneurial activity, albeit modestly.

A striking finding is that FDI has a positive and statistically significant short-run effect on unemployment, implying that foreign investment may initially be channelled into capital-intensive activities or involve restructuring processes that displace workers before generating net job gains. This calls for a shift in policy emphasis towards attracting FDI that is labour-intensive, embedded in domestic value chains, and accompanied by local training initiatives. Taken together, these findings highlight three important policy imperatives; (1) investing in targeted digital skills training and reskilling to mitigate technology-induced job losses; (2) designing a dual-track entrepreneurship support system that differentiates between necessity- and opportunity-driven ventures, helping the former to formalise and the latter to scale; and (3) strategically managing FDI inflows to maximise employment spillovers. By implementing these measures, policymakers can transform the current challenges posed by digitalisation, unemployment, and FDI into drivers of inclusive and sustainable growth.

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