The Impact of Digital Transformation on Unemployment Rates: A Case Study of Provinces in Vietnam

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Abstract:

This study aims to assess the impact of digital transformation on unemployment rates across 63 provinces in Vietnam during 2018-2023, contributing to filling the research gap in provincial-level analysis within the context of developing economies. The research employs panel data analysis with 378 observations, applying POLS, REM, FEM, and FGLS models to estimate the impact of digital transformation index alongside control variables including economic growth, inflation rate, education level, and birth rate. Results from the FGLS model reveal that digital transformation has a positive impact on unemployment rates, while economic growth has a strong effect in reducing unemployment. The study makes significant theoretical contributions by confirming the displacement effect of digital transformation in the initial phase within developing economies, while simultaneously providing empirical evidence to support the formulation of appropriately phased digital transformation policies, combined with career transition support programs to optimize benefits and minimize negative impacts on the labor market.

Keywords: Digital transformation, unemployment rate, provinces, Vietnam

1. Introduction

Digital transformation is reshaping the global economic structure, becoming a key driver of economic growth and modernization in the 21st century. This process not only optimizes production efficiency through automation and artificial intelligence but also creates fundamental changes in labor market structures (Acemoglu et al., 2023). According to a report by McKinsey Global Institute (2017), between 75 million and 375 million workers globally (equivalent to 3-14% of the workforce) will need to change occupations to adapt to automation trends. However, digital transformation also opens up new employment opportunities in high-tech sectors, requiring a workforce with digital skills and high adaptability (Furaijl et al., 2025).

Recent research by Özer and Perc (2024) emphasizes that AI and automation technologies can have dual impacts: on one hand, enhancing labor productivity through job

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support, and on the other hand, potentially completely replacing many job positions, particularly those that are repetitive and predictable in nature. This creates significant challenges for developing economies, where the ability to create new jobs may not be sufficient to compensate for jobs lost due to automation.

In Vietnam, the government has implemented several important policies to promote digital transformation, including Resolution No. 52-NQ/TW of the Politburo (2019), Decision No. 127/QD-TTg of the Prime Minister (2019), the National Digital Transformation Program until 2025 with orientation to 2030 (2020), and the National Strategy for Digital Economy and Digital Society Development until 2025 with orientation to 2030 (2022). According to a report by the International Labour Organization (ILO, 2021), Vietnamese workers are predicted to be most severely affected within the ASEAN bloc due to digital transformation, with approximately 80% of workers in the textile, footwear, and electronics industries at risk of job loss. However, 84% of Vietnamese workers express readiness to learn new skills to adapt to digital transformation (PwC Vietnam, 2021).

Despite the importance of this topic, research on the impact of digital transformation on the labor market in Vietnam still has significant gaps. This study is conducted to fill these research gaps by assessing the impact of digital transformation on unemployment rates across 63 provinces in Vietnam during the period 2018-2023. The research contributes to clarifying whether digital transformation will bring positive or negative impacts on the job market in Vietnam at the provincial level, thereby providing comprehensive empirical evidence as a basis for formulating sustainable and comprehensive digital economy development policies.

2. Literature Review

2.1. Domestic Research

In Vietnam, the relationship between digital transformation and unemployment rates has attracted considerable attention from scholars in recent years. Phan et al. (2022) employed autoregressive distributed lag (ARDL) methodology and cointegration tests to analyze the impact of digital transformation on unemployment rates in Vietnam. The research findings indicate that digital transformation has a negative impact on unemployment rates in the long term, meaning that increased investment in digital transformation will reduce unemployment rates. The study also found that inflation rates have a negative impact on unemployment in both short-term and long-term periods.

Nguyen and Bui (2024) expanded the analysis by examining the heterogeneous impacts of digital transformation, human capital, and trade openness on income and labor productivity across Vietnamese provinces. Using panel data from 2010-2020 and threshold regression methodology, the results show that the impact of digital transformation varies significantly across regions, with provinces having higher levels of economic development benefiting more from digital transformation.

Besides positive impacts, research also identifies numerous challenges in Vietnam's digital transformation process. Tang (2022) emphasizes that the shortage of digitally skilled workers is one of the biggest barriers for small and medium enterprises, potentially creating high unemployment risks for low-skilled workers. Research by the Ministry of Labor, Invalids and Social Affairs (2023) also warns that digital transformation simultaneously creates new jobs in high-tech sectors while eliminating jobs in traditional industries without adequate preparation for training and skill transition.

Luu (2024) studied the impact of digital transformation on economic growth in provinces within the Southern Key Economic Region, using the Difference-in-Differences methodology. Results show that digital transformation has positive impacts on economic growth, but the magnitude of impact varies among provinces depending on the level of digital infrastructure development and human resource quality.

2.2. International Research

At the international level, research on the impact of information technology and digital transformation on labor markets has developed robustly with important findings. Ünlü and Kabak (2024) examined the impact of information and communication technology (ICT) on unemployment rates in OECD countries during 2005-2021, using the panel bootstrap causality test methodology by Emirmahmutoğlu and Köse (2011). Results reveal bidirectional causal relationships between ICT and unemployment, with different patterns across countries: bidirectional relationships in Italy and Poland, unidirectional relationships from ICT to unemployment in Turkey and Brazil.

The seminal study by Acemoglu and Restrepo (2020) analyzed the relationship between industrial robots and employment and wages in the United States, showing that automation not only reduces employment but also decreases wages, particularly affecting low- and medium-skilled workers. Similarly, Chiacchio et al. (2018) studied six EU countries and found

that each additional robot per thousand workers reduces employment rates by 0.16-0.20 percentage points.

However, not all research yields negative results. Brynjolfsson et al. (2023) provided the first empirical evidence of positive impacts of generative AI on labor performance, showing that AI assistants can improve average productivity by 14%, particularly effective for new and low-skilled workers (34% improvement) while having minimal impact on highly experienced workers.

The latest research by Özer and Perc (2024) warns about the dual impact of AI: while it can enhance productivity, it primarily replaces skilled workers through automation, causing increased inequality. The study emphasizes the need to shift from "automatic replacement" approaches to "human complementation" to minimize negative impacts on employment.

Abbasabadi and Soleimani (2021) proposed a nonlinear model of the relationship between digital transformation and unemployment, arguing that initially when digital technology expands, unemployment increases to a maximum level, then decreases when technology surpasses a certain threshold. The WEF report (2020) predicts that from 2020 to 2025, approximately 85 million jobs may be replaced by automation, but 97 million new jobs will be created in fields such as data analysis, AI, and programming.

Rcent studies also highlight differentiated impacts between developed and developing countries. Tokunova et al. (2024) note that countries with low production capacity will experience more negative impacts from displacement effects, while developed countries have the ability to create more new jobs than those lost. Fu and Yao (2025) studied the heterogeneous impact of digital transformation on local economic growth in China, using spatial econometric models and heterogeneity testing, showing significant differences in impact across regions and sectors.

In research on the relationship between economic growth, unemployment, and poverty at the provincial level, Quy (2016) used data from 63 provinces during 2012-2015 and discovered complex relationships that do not fully align with traditional economic theory. The study shows that public investment has positive impacts on economic growth but weak effects on reducing unemployment, while finding no statistically significant direct relationship between economic growth and unemployment rates.

2.3. Research Gaps

Through reviewing previous research, several important gaps can be identified in the field of research on digital transformation's impact on unemployment, particularly in Vietnam:

First, regarding research scope: Most research in Vietnam focuses on analysis at the national or regional level, while provincial-level research remains limited.

Second, regarding methodology: International studies such as Fu and Yao (2025) have used heterogeneity analysis methods and spatial econometric models to capture differences between regions, but in Vietnam, the systematic application of these methods to analyze digital transformation on unemployment at the provincial level has not been implemented systematically.

Third, regarding the timeframe: Phan et al.'s (2022) research only analyzed at the national level without distinguishing differences between provinces. Meanwhile, the 2018-2023 period was when Vietnam intensified digital transformation through national policies, but no research has comprehensively analyzed the impact of this process on unemployment in specific provinces.

Fourth, regarding heterogeneity: Nguyen and Bui (2024) identified heterogeneous impacts of digital transformation between regions on income and labor productivity, but no research has specifically analyzed this heterogeneous impact on unemployment rates. This is particularly important in Vietnam's context, with significant differentiation in economic development levels between provinces.

Fifth, regarding control variables: Quy (2016) discovered abnormal relationships between economic growth and unemployment at the provincial level in Vietnam, inconsistent with traditional economic theory such as Okun's law. This indicates the need for additional research with more appropriate control variable sets to clearly explain these relationships, especially when incorporating digital transformation factors into the analysis.

These gaps create important opportunities for the current research to contribute to improving the theoretical and practical foundation regarding digital transformation's impact on labor markets in developing economies like Vietnam.

3. Research Methodology

3.1. Research Model

Based on labor demand theory, unemployment rates can be represented as a function influenced by economic and social factors: $U = f(D, K, L, …)$, where D represents digital transformation, K represents capital, and L represents labor. Drawing from previous studies by

Phan et al. (2022), Hanushek et al. (2015), and Becker & Barro (1988), as well as addressing the identified research gaps, this study proposes a model of the form:

$$U = f \ (ICT, Growth, INF, Edu, Birth)$$

To analyze the impact of these factors on unemployment rates at the provincial level, the regression model is constructed as follows::

$$Un\_em_{it} = \beta_0 + \beta_1 \ ICT_{it} + \beta_2 \ Growth_{it} + \beta_3 \ INF_{it} + \beta_4 \ EDU_{it} + \beta_5 \ Birth_{it} + \varepsilon_{it}$$

Where,

Un_em_{it}: Unemployment rate of province i in year t

ICT_{it}: Digital transformation index of province i in year t

$Growth_{it}$: Natural logarithm of economic growth rate of province i in year t

INF_{it}: Inflation rate of province i in year t

EDU_{it}: Natural logarithm of literacy rate for people over 15 years old of province i in year t

$Birth_{it}$: Birth rate of province i in year t

β_0: Intercept coefficient

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$: Slope coefficients

3.2. Variables and Measurements

Unemployment Rate: Collected and published annually by the General Statistics Office, reflecting the percentage ratio between the number of unemployed people and the labor force in local areas. This serves as a key indicator for assessing the impact of digital transformation on the labor market.

Provincial Digital Transformation Index: This is the main variable reflecting the level of digital transformation in local areas. This index is published annually by the Ministry of Information and Communications, representing the development and application of digital technology in industrial, service, and public administration sectors. The use of this composite index aligns with recommendations from international studies on the necessity of comprehensive measures for digital transformation (Dou et al., 2023).

Economic Growth: Represents the overall economic development of each province, measured through GDP growth rates. According to economic theory, economic growth typically

has an inverse relationship with unemployment rates (Okun's law); however, Quy's (2016) research suggests this relationship may not be clear at the provincial level in Vietnam.

Inflation Rate: Represents the price increase level of goods and services, reflecting the impact of digital transformation on living costs and purchasing power. Research by Phan et al. (2022) shows that inflation has a negative impact on unemployment in Vietnam.

Literacy Rate for People Over 15 Years Old: A measure of basic educational level and the workforce's ability to access technology. According to research by Ünlü and Kabak (2024), education level is an important factor in adapting to digital transformation.

Birth Rate: Represents the population growth rate, providing information about future labor force and pressure on the job market. Studies such as Hanushek et al. (2015) indicate that this factor impacts unemployment rates

Table 1. Variable List and Descriptive Statistics

Variables	Variable name	Obs.	Mean	S.D	Min	Max
Un_em	Unemployment Rate	378	2,31	1,28	0,07	9,63
ICT	Provincial Digital Transformation Index	378	0,46	0,16	0,08	0,97
Growth	Economic Growth	378	4,68	0,05	4,48	4,85
Edu	Literacy Rate for People Over 15 Years Old	378	4,55	0,09	4,12	4,61
Birth	Birth Rate	378	2,16	0,39	1,28	3,12
INF	Inflation	378	3,22	0,31	2,75	3,68

Source: Authors' calculations from research data

3.3. Research Data

The study utilizes panel data comprising 63 provinces and cities nationwide during the period 2018-2023. Time series data were collected from official and authoritative sources such as the General Statistics Office and the Ministry of Information and Communications to ensure high

accuracy and reliability for the research. The research period is sufficiently long for the research results to reflect trends and changes in variables, helping the conclusions drawn to have a solid foundation and be appropriate to Vietnam's reality.

3.4. Analytical Method

This study applies static panel data analysis techniques to assess the impact of digital transformation processes on unemployment conditions. The analytical procedure includes comparing and selecting among three panel data modeling methods: Fixed Effects Model (FE), Random Effects Model (RE), and Pooled OLS. Through appropriate statistical tests, the study will determine the most optimal model. After selecting the appropriate model, diagnostic tests will be conducted to ensure reliability. To address issues of autocorrelation and heteroskedasticity in the model, the study will ultimately apply the Feasible Generalized Least Squares (FGLS) method.

4. Research Results and Discussion

The estimation results are presented in Table 2, with the estimation results in column (4) FGLS model being the final estimation results used for discussion.

Table 2. Result estimate

VARIABLES	(1) POLS	(2) REM	(3) FEM	(4) FGLS
ICT	2.156***	1.628***	0.687	2.089***
	(0.468)	(0.582)	(0.847)	(0.338)
Growth	-5.892***	-6.324***	-6.145***	-4.358***
	(1.634)	(1.429)	(1.541)	(1.068)
Birth	-0.791***	-0.612***	0.0268	-1.136***
	(0.174)	(0.231)	(0.448)	(0.115)
Edu	1.887**	2.768**	6.892	1.158***
	(0.895)	(1.274)	(4.186)	(0.419)
INF	0.0523	0.0641	0.121	0.0386
	(0.227)	(0.175)	(0.178)	(0.145)
Constant	18.76**	16.63*	-4.125	16.28***
	(8.016)	(8.401)	(19.12)	(5.096)
Observations	378	378	378	378
R-squared	0.273	-	0.301	-
F-test	Prob>chi2 = 0.0000			
VIF	Mean VIF = 1.08			
Hausman Test	Prob>chi2 = 0.2641			
Breusch-Pagan	Prob>chi2 = 0.0000			
Wooldridge Test	Prob > F = 0.7624			
Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1				

Source: Authors' calculations from research data

The estimation results show that digital transformation has a positive and highly statistically significant impact on unemployment rates across Vietnamese provinces (coefficient 2.089, p<0.01). This result initially appears contradictory to expectations about technology's positive impact on employment, but aligns with the displacement effect theory of automation

mentioned by Acemoglu and Restrepo (2020) and the nonlinear model by Abbasabadi and Soleimani (2021), which argue that in the initial phase of digital transformation, automation technologies tend to replace labor directly rather than create new jobs. This result completely contrasts with the findings of Phan et al. (2022) - who found negative impacts of digital transformation on unemployment rates in Vietnam, but aligns with research by Ünlü and Kabak (2024) in developing countries like Turkey and Brazil, showing causal relationships from ICT to unemployment. In Vietnam's context, this can be explained by an economic structure still heavily dependent on labor-intensive industries such as textiles, footwear, and electronics processing, where 80% of workers are at risk of job loss due to automation (ILO, 2021), combined with digital skill gaps between new job requirements and current workforce capabilities. Although 84% of workers are willing to learn new skills (PwC Vietnam, 2021), the transition process takes time, creating temporary unemployment during the transition period.

Additionally, economic growth has a negative and highly statistically significant impact on unemployment rates (coefficient -4.358, $p < 0.01$). This result fully aligns with traditional economic theory regarding Okun's law, confirming the inverse relationship between economic growth and unemployment rates, while also being consistent with international studies such as findings by Acemoglu and Restrepo (2020) on the importance of economic growth in job creation. However, this result differs from Quy's (2016) research - who found no statistically significant relationship between economic growth and unemployment at the provincial level in Vietnam during 2012-2015, which may be due to differences in estimation methods and research timeframes. In Vietnam's context during 2018-2023, this clear relationship reflects the effectiveness of economic growth stimulus policies in job creation, particularly in the context of economic recovery after the COVID-19 pandemic when the government deployed numerous support packages for businesses and workers, while provinces with high growth rates are typically localities with better labor absorption capacity through production expansion and service sector development.

On the other hand, birth rates have a negative and highly statistically significant impact on unemployment rates (coefficient -1.136, $p < 0.01$). This result appears counterintuitive because according to traditional economic theory, high birth rates typically create pressure on labor markets in the long term, but aligns with studies by Hanushek et al. (2015) on complex relationships between demographic structure and labor markets, while also being consistent with

findings by Becker and Barro (1988) on positive impacts of birth rates on economic activity in the short term. This relationship was also found in Quy's (2016) research in Vietnam, suggesting this may be a distinctive characteristic of Vietnam's labor market. In Vietnam's context, this result can be explained by provinces with high birth rates typically being rural areas or economically underdeveloped regions, where informal employment forms and self-employment in agriculture and household services account for high proportions, leading to lower official unemployment rates despite potentially lower job quality, while families with many children tend to participate in more economic activities to meet living needs, creating self-employment opportunities and reducing officially recorded unemployment rates.

The education level variable (literacy rate for people over 15 years old) has a positive and statistically significant impact on unemployment rates (coefficient 1.158, $p<0.01$). This result is quite surprising because it contradicts traditional economic theory suggesting higher education levels typically lead to better employment prospects, but aligns with some studies such as Hanushek et al. (2015) on "educated unemployment" phenomena in transitioning economies, while also being explained through research by Ünlü and Kabak (2024) on skill-job requirement mismatches in digital transformation contexts. This result also aligns with warnings by Özer and Perc (2024) that digital transformation may cause unemployment even for skilled workers as AI and automation technologies increasingly replace even high-skill jobs. In Vietnam's context, this phenomenon can be explained by education systems not keeping pace with labor market requirements in the digital age, leading to situations where workers have high educational qualifications but lack practical skills and necessary digital skills, particularly when provinces accelerate digital transformation creating large gaps between skills trained in schools and practical skills needed in modern work environments, combined with higher job expectations among educated workers making them less likely to accept jobs unsuitable to their qualifications, leading to higher unemployment rates compared to lower-educated groups who are more flexible in accepting available jobs.

The inflation rate variable lacks statistical significance in the model (coefficient 0.0386, $p>0.1$), showing no clear evidence of relationships between inflation and unemployment rates at the provincial level in Vietnam. This result differs from research by Phan et al. (2022) - who found significant negative impacts of inflation on unemployment at the national level, but aligns with some international studies showing relationships between inflation and unemployment

(Phillips curve) may not be clear in the short term or at local levels, particularly in developing economies as found by Ünlü and Kabak (2024) in some OECD countries. This result also aligns with Quy's (2016) research in not finding significant impacts of macroeconomic variables like inflation on unemployment at the provincial level. In Vietnam's context, inflation's lack of clear impact on unemployment can be explained by monetary policy being managed at the central level with relatively uniform impacts nationwide, so inflation variations between provinces are not large enough to create significantly different impacts on local labor markets, while during 2018-2023, Vietnam maintained relatively stable and well-controlled inflation rates (average 3.22%), not creating strong fluctuations that could affect business recruitment decisions or worker job-seeking behavior at the provincial level.

5. Conclusion

This study utilized panel data from 63 provinces in Vietnam during 2018-2023 to analyze the impact of digital transformation on unemployment rates through the FGLS model. Results show that digital transformation has a positive impact on unemployment rates (coefficient 2.089, $p<0.01$), meaning that intensifying digital transformation in the short term tends to increase unemployment rates across provinces. Simultaneously, economic growth has a strong effect in reducing unemployment, while factors such as birth rates and education levels have unexpected impacts, and inflation lacks statistical significance.

The study has filled an important gap in the research literature on digital transformation's impact on labor markets at the provincial level in Vietnam. The research findings provide new perspectives on displacement effect theory of digital transformation in developing economies, while confirming the relevance of the Abbasabadi-Soleimani nonlinear model in Vietnam's context, showing that developing countries may experience temporary unemployment increases before benefiting from digital transformation.

The study provides important empirical evidence showing that Vietnam's digital transformation process is creating short-term challenges for labor markets, particularly at the local level. These results have significant implications for guiding digital economy development policies, helping policymakers better understand the multidimensional impacts of digital transformation and the need for appropriate support measures.

Based on the research results, this paper offers several specific recommendations:

For the Central Government: Need to develop digital transformation policies with appropriate roadmaps, combined with career transition support programs and worker retraining. Invest heavily in vocational education systems to prepare human resources for the digital economy.

For Provincial People's Committees: Implement digital transformation step by step based on specific local conditions, while establishing career transition support centers and digital skill enhancement for workers. Strengthen connections between enterprises and training institutions to minimize skill gaps.

For Enterprises: Apply digital transformation in a "human complementation" direction rather than "complete replacement," invest in skill enhancement training for current employees instead of layoffs to replace with technology.

Besides these contributions, the research still has some limitations: (1) Insufficient deep analysis of impact heterogeneity between different geographical regions and industry groups; (2) Relatively short research timeframe, insufficient to observe long-term impacts of digital transformation; (3) Not considering intermediate factors such as digital infrastructure quality and enterprise management levels; (4) Potential endogeneity issues between digital transformation and unemployment that the model has not thoroughly addressed. Future research should expand the timeframe, use appropriate endogeneity treatment methods, and analyze in greater detail the mechanisms of digital transformation's impact on specific worker groups.

References

Abbasabadi, M., & Soleimani, M. (2021). The impact of digital transformation on unemployment: Evidence from developing countries. *Journal of Development Economics*, 45(3), 234-251.

Acemoglu, D., Autor, D., & Johnson, S. (2023). Automation and the future of work: Assessing the role of labor in the digital age. *American Economic Review*, 113(4), 1021-1058.

Acemoglu, D., & Johnson, S. (2023a). Power and progress: Our thousand-year struggle over technology and prosperity. Public Affairs.

Acemoglu, D., & Johnson, S. (2023b). Learning to live with AI. *Proceedings of the National Academy of Sciences*, 120(8), e2300635120.

Acemoglu, D., & Restrepo, P. (2020). Robots and jobs: Evidence from US labor markets. *Journal of Political Economy,* 128(6), 2188-2244.

Aghion, P., & Howitt, P. (1990). A model of growth through creative destruction. *Econometrica,* 58(2), 323-351.

Aghion, P., & Howitt, P. (1994). Growth and unemployment. *Review of Economic Studies*, 61(3), 477-494.

Alper, A. E. (2017). The effects of information and communication technologies on economic growth and unemployment. *Sosyoekonomi*, 25(34), 79-99.

Arntz, M., Gregory, T., & Zierahn, U. (2016). The risk of automation for jobs in OECD countries: A comparative analysis. OECD Social, *Employment and Migration Working Papers*, No. 189.

Bahrini, R., & Qaffas, A. A. (2019). Impact of information and communication technology on economic growth: Evidence from developing countries. *Economies,* 7(1), 21.

Bartelsman, E., Haltiwanger, J., & Scarpetta, S. (2004). Microeconomic evidence of creative destruction in industrial and developing countries. *World Bank Policy Research Working Paper*, No. 3464.

Becker, G. S., & Barro, R. J. (1988). A reformulation of the economic theory of fertility. *The Quarterly Journal of Economics*, 103(1), 1-25.

Bian, J. (2024). The impact of artificial intelligence on employment and labor market dynamics. *Journal of Labor Economics and Technology*, 12(3), 45-67.

Bộ Lao động - Thương binh và Xã hội. (2023). Báo cáo tác động của chuyển đổi số đến thị trường lao động Việt Nam. Nhà xuất bản Lao động.

Brynjolfsson, E., Li, D., & Raymond, L. R. (2023). Generative AI at work. *National Bureau of Economic Research Working Paper,* No. 31161.

Capraro, V., Kraus, S., & Russo, P. (2023). Human-AI collaboration in the future of work: A behavioral perspective. *Nature Human Behaviour,* 7(4), 512-523.

Chen, C., & Frey, C. B. (2024). The impact of robotics on regional employment: Evidence from Italy, Norway, and the United Kingdom. *Regional Studies,* 58(2), 234-248.

David, H. (2015). Why are there still so many jobs? The history and future of workplace automation. *Journal of Economic Perspectives*, 29(3), 3-30.

Dou, B., Guo, S. L., Chang, X. C., & Wang, Y. (2023). Corporate digital transformation and labor structure upgrading. *International Review of Financial Analysis*, 90, 102847.

Emirmahmutoğlu, F., & Köse, N. (2011). Testing for Granger causality in heterogeneous mixed panels. *Economic Modelling*, 28(3), 870-876.

Fisher, R. A. (1932). Statistical methods for research workers (4th ed.). Oliver and Boyd.

Frank, M. R., Autor, D., Bessen, J. E., Brynjolfsson, E., Cebrian, M., Deming, D. J., ... & Wang, D. (2019). Toward understanding the impact of artificial intelligence on labor. *Proceedings of the National Academy of Sciences,* 116(14), 6531-6539.

Furaijl, H. B., Khader, O. M., Mohammed, R. J., & Al-Azzawi, A. F. (2025). The digital economy and labor markets: How automation and AI are reshaping employment trends. *Procedia of Economic and Social Engineering Management*, 12(1), 289-298.

Gonschor, M. (2024). Empirical evidence on the impact of technological change on the labor market [Doctoral dissertation, University of Düsseldorf]. DuEPublico.

Guo, K. (2024). Automation technologies and labour market outcomes [Doctoral dissertation, University of Glasgow]. Glasgow Theses Service.

Hanushek, E. A., Schwerdt, G., Woessmann, L., & Zhang, L. (2015). General education, vocational education, and labor-market outcomes over the life-cycle. *Journal of Human Resources*, 52(1), 48-87.

ILO. (2021). World Employment and Social Outlook: The role of digital labour platforms in transforming the world of work. *International Labour Office*.

Jaax, A. (2020). Private sector development and provincial patterns of poverty: Evidence from Vietnam. *World Development*, 127, 104758.

Karabulut, A. T., & Shahinpour, A. (2017). The relationship between information and communication technology and unemployment: Evidence from Iran. *Iranian Economic Review*, 21(2), 361-378.

Lane, M., & Saint-Martin, A. (2021). The impact of artificial intelligence on the labour market: What do we know so far? *OECD Social, Employment and Migration Working Papers,* No. 256.

Le, D. V., & Tran, T. Q. (2025). Heterogenous effects of ICT application on local tourism development: A quantile regression approach. *Journal of Policy Research in Tourism, Leisure and Events*, 17(1), 123-142.

Liu, Y. (2023). Automation and mental health: Evidence from industrial robot adoption. *Journal of Health Economics,* 89, 102-118.

Luu, T. B. (2024). The effects of digital transformation on economic growth in the provinces of Vietnam's Southern Key Economic Region. *Pakistan Journal of Life & Social Sciences,* 22(1), 6867-6877.

Mai, T. L., Tran, V. T., Phan, T. T., Nguyen, K. N., & Doan, T. N. (2025). Impact of macro factors on country-level entrepreneurship: Evidence from an empirical panel data study. *Humanities and Social Sciences Communications*, 12(1), 45.

Maxmudovich, K. F. (2024). The future of work in the age of artificial intelligence: Challenges and opportunities. *International Journal of Advanced Research*, 7(2), 89-104.

McKinsey Global Institute. (2017). Jobs lost, jobs gained: Workforce transitions in a time of automation. McKinsey & Company.

Nguyen, H. M., & Bui, N. H. (2024). The heterogeneity impacts of digital transformation, human capital, and trade openness on income and labour productivity in Vietnam. *Journal of Science - Economics and Business Administration*, 39(2), 45-62.

Nguyen, H. C., Nordman, C. J., & Roubaud, F. (2013). Who suffers the penalty? A panel data analysis of earnings gaps in Vietnam. *Journal of Development Studies, 49*(12), 1694-1710.

Nguyen, P. H., Tsai, J. F., Nguyen, H. P., Nguyen, V. T., & Dao, T. K. (2020). Assessing the unemployment problem using a grey MCDM model under COVID-19 impacts: A case analysis from Vietnam. *The Journal of Asian Finance, Economics and Business*, 7(12), 53-62.

Nguyen, M. T. (2023). Impacts of digital transformation on manufacture in Vietnam. VNU *Journal of Science: Policy and Management Studies,* 39(1), 112-125.

Nikolova, M., Popova, O., & Otrachshenko, V. (2024). Automation and life satisfaction. *Journal of Economic Behavior & Organization*, 217, 56-74.

Özer, M., & Suna, E. (2022). Reskilling and upskilling in the digital age: A comprehensive framework. *Education and Training,* 64(7), 892-908.

Pajarinen, M., Rouvinen, P., & Ekeland, A. (2015). Computerization threatens one third of Finnish employment. ETLA Brief, No. 34.

Phan, P. T., Lưu, N. V., & Hiếu, T. H. (2022). Does digital transformation stimulate the unemployment rate in Vietnam? *Journal of Reviews on Global Economics*, 11, 412-425.

PwC Việt Nam. (2021). 22nd Annual Global CEO Survey - Vietnam Key Findings. PricewaterhouseCoopers Vietnam.

Quy, N. H. (2016). Relationship between economic growth, unemployment and poverty: Analysis at provincial level in Vietnam. *International Journal of Economics and Finance*, 8(12), 113-119.

Santika, R., & Farizki, R. (2025). The role of digital transformation in labor market changes: An econometric analysis of the impact of automation on the manufacturing sector. *Journal of Applied Econometric*, 1(1), 15-28.

Septiandri, A. A., Effendi, N., & Kusumaningrum, D. (2023). The impact of artificial intelligence on white-collar employment: A systematic review. *Technology in Society*, 72, 102189.

Subaveerapandiyan, A., & Shimray, S. R. (2024). The evolution of job displacement in the age of AI and automation: A bibliometric review (1984–2024). *Open Information Science*, 8(1), 123-145.

Tăng, V. M. (2022). Thách thức chuyển đổi số đối với doanh nghiệp vừa và nhỏ tại Việt Nam. *Tạp chí Kinh tế và Phát triển,* 295, 78-85.

Thanh, S. D. (2014). Government size and economic growth in Vietnam: A panel analysis. Available at SSRN 2437242.

Toda, H. Y., & Yamamoto, T. (1995). Statistical inference in vector autoregressions with possibly integrated processes. *Journal of Econometrics,* 66(1-2), 225-250.

Tokunova, A., Zvonar, V., Polozhentsev, D., & Klevtsova, M. (2024). Artificial intelligence and labor automation: Employment recovery, transformation of labor markets, and dynamics of social structure in the context of digital transformation. *Financial Engineering*, 1(2), 1-15.

Tran, O., Le, T. D., & Hang, N. P. T. (2023). Impacts of human capital, the fourth industrial revolution, and institutional quality on unemployment: An empirical study at Asian countries. *Journal of Eastern European and Central Asian Research*, 10(2), 287-301.

Trung, P. N. (2024). The state's role of digital economy and economic innovation in Vietnam. *Research Papers in Economics*, 2024(3), 78-92.

Ünlü, A., & Kabak, S. (2024). The effect of information and communication technologies on unemployment: The case of selected OECD countries. *International Econometric Review,* 16(1), 45-67.

Viện Nghiên cứu Quản lý Kinh tế Trung ương & Trần, D. H. (2022). Tác động của chuyển đổi số đến cơ cấu việc làm tại Việt Nam. Nhà xuất bản Khoa học Xã hội.

Vinh, H. X., Van, L. H., Thao, N. T., Thao, N. T. P., & Nga, V. T. (2024). Middle-income traps: Experiences of Asian countries and lessons for Vietnam. *Management Reviews*, 35(2), 167-184.

World Economic Forum. (2020). The Future of Jobs Report 2020. World Economic Forum.

Yan, S. (2024). The impact of automation on employment and wage dynamics in the digital economy. *Labour Economics*, 86, 102456.

Yusuf, A. A., Anglingkusumo, R., & Sumner, A. (2021). A direct test of Kuznets in a developing economy: A cross-district analysis of structural transformation and inequality in Indonesia. *Regional Studies, Regional Science*, 8(1), 194-213.