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ICT SERVICES TRADE, DIGITAL ADOPTION, LABOUR PRODUCTIVITY AND EMPLOYMENT IN ADVANCED AND DEVELOPING ECONOMIES: A PANEL DATA ANALYSIS

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ABSTRACT

This article examines the relationship between ICT services trade, digital adoption, employment, and labour productivity in advanced and developing economies. The analysis uses panel data for 100 economies from 2006 to 2024, comprising 31 advanced and 69 developing economies classified according to the IMF World Economic Outlook.

The empirical approach applies fixed-effects panel regressions with country and year effects, country-clustered robust standard errors, and inverse hyperbolic sine transformations. Separate models are estimated for advanced and developing economies using two dependent variables: the employment-to-population ratio and GDP per person employed. The results reveal substantial differences between the two country groups. In advanced economies, ICT services exports and Internet use are positively associated with employment, while ICT-related variables show no stable relationship with labour productivity. In developing economies, ICT services exports and imports are not statistically significant in either model. However, Internet use is negatively associated with employment and positively associated with labour productivity, suggesting that digital adoption may support productivity-enhancing transformation while contributing to labour-market restructuring. Robustness checks excluding GDP per capita and using one-year lags confirm the consistent role of Internet use. By contrast, ICT services imports show no robust association with either employment or productivity. The findings underline the importance of distinguishing between ICT services trade and broader digital adoption when assessing labour-market and productivity outcomes.

Keywords: *ICT services trade, digital adoption, Internet use, employment, labour productivity, advanced economies, developing economies, panel data*

1. INTRODUCTION

The rapid expansion of information and communication technologies (ICT) has become a defining feature of contemporary economic development. ICT no longer functions solely as infrastructure supporting production and exchange; it increasingly shapes productivity, firm organisation, international competitiveness, and labour-market structures. As a general-purpose technology, ICT affects economic performance through efficiency gains, lower transaction costs, innovation, organisational change, and improved access to information (Cardona, Kretschmer, & Strobel, 2013). At the macroeconomic level, the ICT revolution is widely recognised as an important driver of global economic growth, although its effects depend on complementary factors such as skills, institutional quality, business practices, and market openness (Jorgenson & Vu, 2016; OECD, 2019).

The expansion of ICT services trade has added a further dimension to digital transformation. Cross-border ICT-enabled services have increased the tradability of knowledge-intensive activities and reduced barriers to service delivery. Earlier studies show that Internet expansion promotes trade in services and supports both exports and imports (Freund & Weinhold, 2002; Choi, 2010). More recent evidence indicates that participation in ICT services markets is associated not only with trade performance but also with broader macroeconomic outcomes, including economic growth (Oliinyk, 2023). ICT services exports and imports may therefore represent important channels through which digitalisation influences employment and labour productivity.

Despite a substantial body of research, several issues remain insufficiently explored. Much of the literature focuses on aggregate growth or productivity, while the employment effects of ICT remain more ambiguous and context-dependent (Acemoglu & Restrepo, 2019; Goaied & Sassi, 2019). Moreover, many studies examine ICT capital, Internet diffusion, or digital adoption separately, while relatively few integrate these dimensions with ICT services trade within a unified empirical framework. The effects of ICT are also likely to vary across country groups because digitalisation interacts with levels of development, absorptive capacity, skills, and institutional conditions (Papaioannou & Dimelis, 2007; Oliinyk et al., 2024; Nayyar et al., 2024). In advanced economies, ICT may contribute more strongly to productivity growth and service-sector upgrading, whereas in developing economies it may have more immediate implications for labour-market access, inclusion, and structural transformation (Peña, Cusolito, & Lederman, 2020; World Bank, 2016; UNCTAD, 2024).

Against this background, this article examines the relationship between ICT services trade, digital adoption, employment, and labour productivity in advanced and developing economies. The analysis uses annual panel data for 100 economies from 2006 to 2024, comprising 31 advanced and 69 developing economies. The empirical framework draws on a reduced-form interpretation of the Solow growth model. ICT services exports, ICT services imports, and Internet use are employed as technology-related indicators, while gross capital formation, education, services value added, demographic structure, institutional quality, and other relevant factors are included as control variables.

The main objective is to determine whether ICT services exports, ICT services imports, and Internet use are associated differently with employment and labour productivity across economies at different stages of development. Rather than treating digitalisation as a homogeneous process, the study distinguishes between external digital integration, reflected in ICT services trade, and domestic digital diffusion, captured by Internet use. This distinction is important because these dimensions represent different mechanisms of digital transformation and may produce different labour-market and productivity outcomes.

The article contributes to the literature in three ways. First, it analyses ICT services trade and domestic digital adoption within a common empirical framework. Second, it examines both employment and labour productivity rather than focusing on only one dimension of economic performance. Third, it compares advanced and developing economies, allowing the relationship between digitalisation and economic outcomes to vary according to the level of development.

The remainder of the article is organised as follows. The next section reviews the literature on ICT, productivity, employment, and ICT services trade. The subsequent section describes the data, variables, methodology, and econometric specification. The empirical results and robustness checks are then presented and discussed. The final section summarises the main conclusions and policy implications.

2. LITERATURE REVIEW

A substantial body of research examines ICT as a general-purpose technology that can improve economic performance through efficiency gains, innovation, organisational change, lower transaction costs, and better access to information. However, the empirical evidence is not uniform. Cardona et al. (2013) find that ICT is generally positively associated with productivity, but the estimated effects depend on the level of aggregation, ICT measurement, model specification, and the availability of complementary capabilities. Jorgenson and Vu (2016) identify ICT as an important source of global economic growth, while OECD (2019) stresses that stronger outcomes require complementary skills, managerial capacity, institutional quality, and openness. ICT should therefore not be treated as an isolated technological input, since its relationship with productivity and employment depends on the broader economic environment.

Cross-country studies provide important evidence on the macroeconomic role of ICT, although their conclusions vary with the indicators and estimation methods used. Papaioannou and Dimelis (2007), applying an augmented production-function framework, find that ICT contributes to labour productivity growth in both developed and developing economies. Vu (2011) similarly reports a positive contribution of ICT to economic growth. Niebel (2018), however, finds a positive relationship between ICT capital and GDP growth but no statistically significant differences in ICT output elasticities across developing, emerging, and developed economies. This suggests that differences between country groups may be less visible when ICT is measured primarily through capital or investment. Results may also vary depending on whether studies use cross-sectional averages, pooled observations, fixed effects, or other panel-data techniques.

Firm-level research provides more detailed evidence on the underlying mechanisms. Commander et al. (2011) report a positive relationship between ICT capital and productivity in Brazil and India, while Gal et al. (2019) find that digital adoption improves productivity among European firms, although the gains are weaker where skills are limited. Borowiecki et al. (2021) and Nucci et al. (2023) also identify positive productivity effects, particularly in service industries. These studies highlight the importance of management quality, skills, innovation, and sectoral characteristics. They also help explain why macroeconomic results may differ, since national indicators aggregate firms and sectors with widely varying digital capabilities.

Another strand of the literature links digital connectivity to international trade in services. Freund and Weinhold (2002) show that the Internet promotes international services trade by reducing communication costs and barriers to cross-border delivery. Choi (2010) confirms that Internet expansion increases total services trade, exports, and imports. More recently, Oliinyk (2023) finds that participation in ICT services markets is associated with broader macroeconomic outcomes, including economic growth, inflation, and exchange-rate movements. These findings support the inclusion of ICT services trade in macroeconomic analysis. Nevertheless, most studies focus on trade or aggregate growth, leaving the employment and productivity implications of ICT services exports and imports comparatively underexplored.

ICT services exports and imports may also operate through different channels. Exports may reflect domestic digital competitiveness, the capacity to produce knowledge-intensive services, and integration into global digital markets. Imports may facilitate access to foreign technology and digital inputs, but they may also indicate dependence on external ICT solutions. Imported services can improve efficiency and technology diffusion when domestic firms possess sufficient absorptive capacity. Their effects may be weak or negative when imported inputs are poorly integrated or substitute for domestic production. ICT services exports and imports should therefore be analysed separately rather than combined into a single measure of digitalisation.

The employment effects of digitalisation are even more ambiguous than its productivity effects. Acemoglu and Restrepo (2019) argue that technology can displace labour through automation while also creating new tasks through reinstatement effects. Goaied and Sassi (2019) identify labour-saving effects of ICT adoption, whereas Hjort and Poulsen (2019) find that access to fast Internet increased employment in Africa, including among less-educated workers. These contrasting findings indicate that employment effects depend on the type of technology, labour-market structure, skill composition, and stage of development. A positive relationship with productivity therefore does not necessarily imply a positive relationship with employment.

Recent studies similarly emphasise that digitalisation can support productivity and inclusion only under favourable conditions. Nayyar et al. (2024) argue that digital technologies can improve labour-market matching, reduce business inefficiencies, and support intangible-capital accumulation, but their effects on employment and wages remain uneven. Peña et al. (2020) show that digital-technology adoption is associated with higher productivity and changes in factor demand in developing economies, although these gains depend on firm capabilities and the business environment. The World Bank (2016, 2023) and UNCTAD (2024) likewise stress that digital access alone is insufficient for inclusive development. Complementary investments in skills, institutions, business upgrading, and productive capacity remain essential.

Several methodological and conceptual differences help explain the inconsistency of previous findings. First, ICT capital, investment, Internet use, digital readiness, and ICT services trade capture different dimensions of digital transformation. Second, GDP growth, labour productivity, employment, wages, and trade flows respond through different mechanisms. Third, firm-level studies identify microeconomic channels, while country-level studies capture broader structural relationships. Fourth, cross-sectional models largely reflect differences between countries, whereas fixed-effects models focus on changes within countries over time. Finally, endogeneity remains a persistent challenge because ICT adoption, productivity, employment, and income may be jointly determined.

The present study addresses these gaps in several ways. It distinguishes among ICT services exports, ICT services imports, and Internet use rather than treating digitalisation as a single aggregate factor. It examines both employment and labour productivity and compares advanced and developing economies using a consistent IMF-based classification. The empirical analysis applies country and year fixed effects to control for time-invariant national characteristics and common global shocks. It also includes controls for capital formation, education, services value added, institutional quality, and demographic structure, reflecting the complementary conditions emphasised in the literature.

Overall, the literature indicates that ICT is relevant to economic performance, but its effects are heterogeneous, conditional, and sensitive to measurement and methodology. Productivity effects are more consistently documented than employment effects, while the labour-market consequences of digitalisation remain context-dependent. Limited attention has been given to studies that jointly examine ICT services exports, ICT services imports, Internet use, employment, and labour productivity across advanced and developing economies. This study addresses that gap within a unified panel-data framework and interprets the estimated relationships as conditional associations rather than causal effects.

3.METHODOLOGY

3.1. RESEARCH DESIGN AND THEORETICAL BACKGROUND

This study applies a panel-data regression framework to examine the relationship between ICT services trade, digital adoption, labour productivity, and employment in advanced and developing economies over the period 2006-2024.

The models are estimated separately for the two country groups to identify whether the associations between ICT-related variables and labour-market outcomes differ by level of development. This distinction is important because advanced economies generally have stronger absorptive capacity, more developed service sectors, better digital infrastructure, and more mature labour markets. In developing economies, digital transformation may operate through different channels, including labour-market restructuring, service-sector expansion, deeper trade integration, and the gradual diffusion of Internet use.

The theoretical framework draws on a reduced-form interpretation of the Solow growth model (Solow, 1957). In the standard Cobb-Douglas production function, output is determined by capital, labour, and technology:

$$Y_{it} = A_{it} \times K_{it}^{\alpha} \times L_{it}^{1-\alpha} \tag{1}$$

where (Y) denotes output, (A) represents technology or total factor productivity, (K) is capital, (L) is labour, and (\alpha) is the output elasticity of capital.

The Solow framework guides the selection of variables representing technology, capital accumulation, labour-market outcomes, and broader macroeconomic conditions. ICT services exports, ICT services imports and Internet use are used as technology-related indicators, while gross capital formation serves as a proxy for capital accumulation. Education, services value added, demographic structure, and institutional quality are included as complementary control variables.

3.2. COUNTRY SAMPLE

The analysis is based on a cross-country panel dataset covering the period 2006-2024. Countries are divided into two groups according to the International Monetary Fund classification used in the World Economic Outlook: advanced economies and emerging market and developing economies. For the purposes of this article, the IMF category “emerging market and developing economies” is referred to as “developing economies” (International Monetary Fund, 2025). The final sample includes 100 economies: 31 advanced economies and 69 developing economies (Table 1).

Table 1. Data description

Group	Countries
Advanced economies (31)	Australia; Austria; Belgium; Canada; Croatia; Cyprus; Czechia; Denmark; Estonia; Finland; Germany; Iceland; Israel; Italy; Japan; Korea, Republic of; Latvia; Lithuania; Netherlands; New Zealand; Norway; Poland; Portugal; Singapore; Slovakia; Slovenia; Spain; Sweden; Switzerland; United Kingdom; United States of America.
Developing economies (69)	Algeria; Argentina; Azerbaijan; Bahrain; Bangladesh; Belarus; Benin; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Burkina Faso; Cameroon; Chile; Colombia; Comoros; Congo; Congo, Democratic Republic of the; Costa Rica; Côte d’Ivoire; Dominican Republic; Ecuador; Egypt; Ethiopia; Georgia; Guatemala; Guinea; Honduras; Hungary; Indonesia; Iran, Islamic Republic of; Kazakhstan; Kenya; Kyrgyzstan; Lesotho; Macedonia, North; Madagascar; Malaysia; Maldives; Mali; Malta; Mauritania; Mauritius; Moldova, Republic of; Montenegro; Namibia; Niger; Oman; Pakistan; Panama; Romania; Russian Federation; Rwanda; Saudi Arabia; Senegal; Serbia; South Africa; Sri Lanka; Tajikistan; Tanzania, United Republic of; Thailand; Togo; Tunisia; Uganda; Ukraine; United Arab Emirates; Uruguay; Uzbekistan.

Source: authors’ compilation

3.3. VARIABLES AND DATA SOURCES

The study uses two dependent variables to capture labour-market performance and labour productivity. The employment-to-population ratio for individuals aged 15 and above (EMPL) is measured as a percentage of the population aged 15+, based on modelled ILO estimates from World Bank Open Data (2026). Labour productivity is represented by GDP per person employed (GDPpPE), measured in constant 2021 purchasing power parity dollars and obtained from World Bank Open Data (2026).

The main explanatory variables capture ICT services trade and digital adoption. ICT services exports (ICTExport) and ICT services imports (ICTImport) are measured as percentages of GDP using data from UNCTADstat (2026). Internet use (IntUser) is measured as the percentage of individuals using the Internet and is obtained from World Bank Open Data (2026).

The models also include several control variables. GDP growth (GDP), measured as the annual percentage change in GDP, captures short-term economic dynamics. GDP per capita (GDPpC), expressed in current U.S. dollars, controls for the level of economic development. Both variables are obtained from World Bank Open Data (2026). Inflation is represented by the annual percentage change in the consumer price index (CPI), while trade openness (TO) is measured as the sum of exports and imports of goods and services as a percentage of GDP. Both indicators are obtained from UNCTADstat (2026).

Political Stability and Absence of Violence/Terrorism (PS) controls for the institutional and political environment. Gross capital formation (GCF) captures investment and capital accumulation, while tertiary school enrolment (SE) serves as a proxy for human capital. Services value added (ServVA) controls for the sectoral structure of the economy, and the age dependency ratio (ADR) captures demographic pressure on the working-age population. The relevant control-variable data are obtained from World Bank Open Data and UNCTADstat (2026).

Table 2. Variables used in the regression model

Variable type	Code	Indicator	Measurement	Source
Dependent	EMPL	Employment to population ratio, 15+, total	% of population aged 15+	World Bank Open Data (2026)
Dependent	GDPpPE	GDP per person employed	constant 2021 PPP $	World Bank Open Data (2026)
Independent	IntUser	Individuals using the Internet	% of population	World Bank Open Data (2026)
Independent	ICTExport	ICT services exports	% of GDP	UNCTADstat (2026)
Independent	ICTImport	ICT services imports	% of GDP	UNCTADstat (2026)
Control	GDP	GDP growth	annual %	World Bank Open Data (2026)
Control	GDPpC	GDP per capita	current US$	World Bank Open Data (2026)
Control	CPI	Consumer price index	annual consumer price change / price-level indicator	UNCTADstat (2026)
Control	TO	Trade openness	trade in goods and services as % of GDP	UNCTADstat (2026)
Control	PS	Political Stability and Absence of Violence/Terrorism	estimate from (-2,5) to (2,5)	World Bank Open Data (2026)
Control	GCF	Gross capital formation	% of GDP	World Bank Open Data (2026)
Control	SE	School enrollment, tertiary	% gross	World Bank Open Data (2026)
Control	ServVA	Services, value added	% of GDP	World Bank Open Data (2026)
Control	ADR	Age dependency ratio	% of working-age population	World Bank Open Data (2026)

Source: authors' compilation

3.4. DATA TRANSFORMATION

The study covers the period from 2006-2024. To improve model quality and facilitate interpretation, the variables were transformed using inverse hyperbolic sine transformation, which is applied to all variables:

$$IHS(\mathrm{x}) = \operatorname{asinh}(x) = \ln\left(x + \sqrt{x^2 + 1}\right) \tag{2}$$

where x denotes the original value of the variable.

1.1. BASELINE ECONOMETRIC SPECIFICATION

The baseline empirical model is estimated separately for each dependent variable and each country group. The two dependent variables are employment and labour productivity. The baseline panel specification is as follows:

$$\begin{aligned} IHS(Y_{it}) = {} & \beta_0 + \beta_1 IHS(ICTexport_{it}) + \beta_2 IHS(ICTimport_{it}) + \beta_3 IHS(IntUser_{it}) + \\ & + \beta_4 IHS(GDP_{it}) + \beta_5 IHS(GDPpC_{it}) + \beta_6 IHS(CPI_{it}) + \beta_7 IHS(TO_{it}) + \\ & + \beta_8 SL(PS_{it}) + \beta_9 IHS(GCF_{it}) + \beta_{10} IHS(SE_{it}) + \beta_{11} IHS(SEervVA_{it}) + \\ & + \beta_{12} IHS(ADR_{it}) + \mu_i + \lambda_i + \in_i \end{aligned} \tag{3}$$

where Y_{it} denotes either employment or labour productivity in country i and year t. The term μ_i represents country fixed effects, λ_i represents year fixed effects, and $\in_i$ is the error term.

The same specification is estimated separately for four country–outcome combinations: advanced economies with EMPL and GDPpPE as the dependent variables, and developing economies with EMPL and GDPpPE as the dependent variables.

Country fixed effects control for unobserved time-invariant characteristics, including geography, long-term institutional traditions, historical economic structures, and persistent differences in labour-market organisation. Year fixed effects account for global shocks and common time-specific influences, such as the global financial crisis, the COVID-19 pandemic, digitalisation trends, and other international macroeconomic developments affecting all countries in a given year.

3.5. ESTIMATION STRATEGY AND MODEL SELECTION

The empirical analysis employs a panel-data estimation strategy. Because the dataset contains repeated observations for each country over time, three alternative specifications are considered: pooled ordinary least squares, fixed effects, and random effects. This allows comparison between a pooled model and specifications that account for unobserved country-specific heterogeneity.

The starting point of the estimation strategy is the pooled OLS model (Fisher, 1925):

$$IHS(Y_{it}) = \beta_0 + \beta X_{it} + \in_{it} \tag{4}$$

where Y_{it} denotes either employment or labour productivity in country i and year t, is the vector of explanatory variables, β is the vector of estimated coefficients, and $\in_{it}$ is the error term.

The pooled OLS model treats all country-year observations as homogeneous after controlling for the included explanatory variables. This assumption may be restrictive in cross-country macroeconomic analysis because countries differ in persistent characteristics, including institutional traditions, labour-market structures, geography, historical development paths, and technological capacity. When these unobserved characteristics are correlated with the regressors, pooled OLS estimates may be biased.

To address this limitation, the study also estimates a fixed-effects model, specified as follows:

$$IHS(Y_{it}) = \beta X_{it} + \mu_i + \lambda_i + \in_{it} \tag{5}$$

where μ_i denotes country-specific effects and λ_i denotes year-specific effects. Country effects capture time-invariant unobserved heterogeneity across economies, while year effects control for common shocks affecting all countries in a given year, such as global crises, technological waves, or worldwide macroeconomic changes. The fixed effects estimator therefore focuses on within-country variation over time.

In addition, the random effects model is estimated (Wallace & Hussain, 1969):

$$IHS(Y_{it}) = \beta X_{it} + \alpha_i + \epsilon_{it} \tag{6}$$

where α denotes the unobserved country-specific random effect. The random-effects model assumes that these country effects are uncorrelated with the explanatory variables. When this assumption holds, the random-effects estimator is more efficient than the fixed-effects estimator because it uses both within-country and between-country variation. When the assumption is violated, the fixed-effects estimator is preferred because it remains consistent in the presence of correlation between unobserved country characteristics and the regressors.

Several diagnostic tests are used to select the appropriate model specification, with the results reported in the empirical section. First, the F-test compares pooled OLS with the fixed-effects model by testing whether the country-specific effects are jointly equal to zero. Under the null hypothesis, no significant country effects are present and pooled OLS is adequate. Rejection of the null indicates that country-specific effects are significant and that the fixed-effects model is more appropriate.

The test statistic is expressed as:

$$F = \frac{(RSS_{OLS} - RSS_{FE}) / q}{RSS_{FE} / (NT - n - k)} \tag{7}$$

where RSS_{OLS} and RSS_{FE} denote the residual sums of squares from the pooled OLS and fixed-effects models, respectively; (N) is the number of countries; (T) is the number of time periods; (q=N-1) is the number of restrictions; and (k) is the number of explanatory variables. Rejection of the null hypothesis indicates that country-specific effects are relevant and that the fixed-effects model is preferable to pooled OLS.

The Breusch–Pagan Lagrange Multiplier test compares pooled OLS with the random-effects model by testing whether the variance of the unobserved country-specific component is equal to zero. Under the null hypothesis, no random effects are present and pooled OLS is appropriate. Rejection of the null indicates that country-level heterogeneity is statistically significant and that the random-effects model is preferable to pooled OLS (Breusch & Pagan, 1980). The test therefore determines whether the panel structure of the data should be explicitly incorporated into the estimation.

The Hausman test is used to choose between the fixed-effects and random-effects models. It examines whether the unobserved country-specific effects are correlated with the explanatory variables. Under the null hypothesis, the random-effects estimator is consistent and efficient because the individual effects are uncorrelated with the regressors. Rejection of the null indicates that the random-effects estimator is inconsistent and that the fixed-effects model should be preferred (Hausman, 1978).

4. RESULTS

4.1. DESCRIPTIVE STATICTICS AND MODEL DIAGNOSTICS

The empirical analysis uses an unbalanced panel covering the period 2006–2024. The baseline sample comprises 513 country-year observations for 31 advanced economies and 1,024 observations for 69 developing economies. The unbalanced structure reflects differences in data availability across countries and indicators, which are common in cross-country macroeconomic datasets.

Table 3 reports descriptive statistics for the variables included in the baseline models. The results reveal substantial structural differences between the two country groups. Advanced economies exhibit higher average labour productivity, Internet use, ICT services export intensity, GDP per capita, tertiary education enrolment, and political stability. Average GDP per person employed is approximately USD 105,4 thousand in advanced economies, compared with USD 43,7 thousand in developing economies. The average share of Internet users is 81,9% and 43,5%, respectively, while ICT services exports account for an average of 1,87% of GDP in advanced economies and 0,70% in developing economies.

Developing economies display greater dispersion across most indicators, particularly labour productivity, Internet use, GDP per capita, tertiary education, and the age dependency ratio. This variation reflects the heterogeneity of the group in terms of income, institutional development, demographic structure, digital infrastructure, and integration into international services trade. It also supports the decision to estimate separate models for advanced and developing economies.

The correlation analysis shows that ICT services exports, ICT services imports, and Internet use are not strongly correlated and therefore capture distinct dimensions of digitalisation. In advanced economies, the correlations are 0,089 between ICTExport and ICTImport, 0,195 between ICTExport and IntUser, and 0,315 between ICTImport and IntUser. The corresponding values for developing economies are 0,041, 0,225, and 0,226.

Among advanced economies, the strongest correlations are observed between GDP growth and trade openness (-0,575), Internet use and GDP per capita (0,564), and ICT services exports and trade openness (0,515). These values are moderate and do not suggest severe linear dependence among the regressors.

Stronger correlations are present in the developing-economy sample. GDP per capita is negatively correlated with the age dependency ratio (-0,810), while Internet use is positively correlated with tertiary enrolment (0,778), and GDP per capita is positively correlated with tertiary enrolment (0,775). These relationships indicate that income, education, Internet diffusion, and demographic structure are closely connected in developing economies. They should therefore be considered jointly in the regression analysis, although the relatively high correlations also warrant formal multicollinearity checks.

Table 3. Descriptive statistics of IHS-transformed variables, baseline sample, 2006-2024

Variable	Advanced economies: Mean	Advanced economies: SD	Developing economies: Mean	Developing economies: SD
EMPL	4,7394	0,1126	4,7011	0,2079
GDPpPE	12,2200	0,2794	11,0118	0,9531
ICTExport	1,1093	0,7058	0,5526	0,5275
ICTImport	0,7430	0,5841	0,4779	0,4627
IntUser	5,0818	0,1917	4,0083	1,2079
GDP	27,2141	1,6293	25,3709	1,6090
GDPpC	11,1717	0,5457	9,0122	1,1646
CPI	1,3287	0,9117	1,9766	1,1363
TO	5,2398	0,4656	4,9435	0,5803
PS	0,6653	0,4249	-0,2780	0,6550
GCF	3,8385	0,1736	3,8745	0,3506
SE	4,9945	0,1964	3,9491	0,9416
ServVA	4,8445	0,0919	4,6260	0,1859
ADR	4,6160	0,1509	4,7215	0,3009

Source: authors' calculations

To assess multicollinearity more formally, variance inflation factors were calculated for all explanatory variables. In the advanced-economy sample, the maximum VIF is 3,103, indicating that multicollinearity is not a serious concern. In the developing-economy sample, the highest VIF is 6,415 for GDP per capita. This suggests moderate overlap with other development-related variables, particularly tertiary education, Internet use, and the age dependency ratio, but does not indicate severe multicollinearity.

The next stage is to determine whether pooled OLS, fixed effects, or random effects provide the most appropriate panel specification. Because the dataset contains repeated observations for the same countries over time, ignoring country-specific heterogeneity may produce biased estimates. As reported in Table 4, pooled OLS is first compared with the fixed-effects model using the F-test. The null hypothesis states that the country and year effects are jointly equal to zero and that pooled OLS is adequate. Rejection of the null indicates that unobserved effects are statistically significant and that the fixed-effects model is more appropriate.

Table 4. F-test for fixed effects against pooled OLS

Group	Dependent variable	F-statistic	p-value
Advanced economies	EMPL	105,523	<0,001
Advanced economies	GDPpPE	150,149	<0,001
Developing economies	EMPL	206,000	<0,001
Developing economies	GDPpPE	169,481	<0,001

Source: authors’ calculations

The F-test strongly rejects pooled OLS in all four baseline models, indicating that country and year effects are jointly significant. Pooled OLS is therefore unsuitable as the main estimator because it does not adequately account for unobserved country heterogeneity or common time shocks.

Random effects models were also considered. The random-intercept specification confirms that country-level heterogeneity is statistically significant relative to pooled OLS. However, the random-effects estimator assumes that unobserved country-specific effects are uncorrelated with the explanatory variables. This assumption is restrictive in cross-country macroeconomic analysis, since ICT services trade, Internet use, GDP per capita, education, institutional quality, and sectoral structure are likely to be related to persistent country characteristics.

The Hausman test was therefore used to compare the fixed-effects and random-effects estimators. The results are reported in Table 5.

Table 5. Hausman test for fixed effects versus random effects

Group	Dependent variable	Hausman statistic	p-value	Interpretation
Advanced economies	EMPL	15,201	0,231	Random effects are statistically acceptable, but FE is retained as conservative baseline
Advanced economies	GDPpPE	61,299	<0,001	Fixed effects preferred
Developing economies	EMPL	51,742	<0,001	Fixed effects preferred
Developing economies	GDPpPE	—	—	Test inconclusive due to covariance-matrix limitations; FE retained as conservative baseline

Source: authors’ calculations

The Hausman diagnostics provide further support for using fixed effects as the main specification. The test rejects the random-effects assumption for the labour-productivity model in advanced economies and the employment model in developing economies, indicating that unobserved country-specific factors are correlated with the regressors. For the advanced-economy employment model, random effects remain statistically admissible, but fixed effects are retained to ensure consistency across specifications and because the analysis focuses on within-country changes over time. For the developing-economy productivity model, the Hausman test is inconclusive because the covariance-difference matrix is not positive definite. Fixed effects are therefore retained as the more conservative option, since they do not require the orthogonality assumption imposed by random effects.

These diagnostics determine the final estimation strategy. Pooled OLS is reported only as a benchmark because the F-tests reject the absence of country and year effects. Random effects are also considered, but their identifying assumption is restrictive in this cross-country setting. Fixed effects are therefore used as the baseline estimator because they control for unobserved time-invariant country characteristics and common year-specific shocks.

Heteroskedasticity was assessed using the Breusch–Pagan test. The null hypothesis of homoskedasticity is rejected in all four baseline models. The test statistics are 118,71 for advanced economies with employment, 156,46 for advanced economies with labour productivity, 105,87 for developing economies with employment, and 63,04 for developing economies with labour productivity, with ($p<0,001$) in every case. Accordingly, inference is based on country-clustered robust standard errors, which account for heteroskedasticity and within-country dependence over time.

Overall, the descriptive and diagnostic results support the use of fixed-effects models with country-clustered robust standard errors. The descriptive statistics confirm substantial differences between advanced and developing economies, while the correlation and VIF diagnostics indicate that multicollinearity is not severe. Nevertheless, GDP per capita warrants additional robustness analysis in the developing-economy sample. The model-selection tests reject pooled OLS, and the Hausman diagnostics generally favour fixed effects as the main empirical specification.

4.2. REGRESSION ANALYSIS

Table 6 presents the baseline fixed effects regression results for advanced and developing economies over the period 2006-2024. The reported p-values are based on country-clustered robust standard errors. The models include both country and year fixed effects, which makes it possible to control for unobserved time-invariant country characteristics and common shocks affecting all countries in particular years.

Table 6. Fixed effects regression results, 2006-2024

Variable	Advanced economies EMPL	Advanced economies GDPpPE	Developing economies EMPL	Developing economies GDPpPE
ICTExport	0,011** (0,043)	-0,001 (0,878)	0,013 (0,455)	-0,023 (0,301)
ICTImport	0,013 (0,143)	-0,012 (0,194)	0,005 (0,689)	-0,016 (0,459)
IntUser	0,061*** (0,003)	0,004 (0,935)	-0,021** (0,043)	0,030** (0,048)
GDP	-0,052 (0,381)	-0,152* (0,092)	-0,090 (0,391)	-0,043 (0,786)
GDPpC	0,205*** (0,000)	0,434*** (0,000)	0,154 (0,120)	0,327** (0,039)
CPI	0,007*** (0,006)	0,011*** (0,004)	0,003 (0,287)	-0,004 (0,567)
TO	0,092*** (0,001)	0,153*** (0,001)	0,012 (0,447)	-0,024 (0,407)
PS	0,012 (0,294)	0,007 (0,735)	-0,004 (0,776)	0,051** (0,042)
GCF	0,088*** (0,000)	-0,048** (0,045)	0,019 (0,378)	0,048 (0,104)
SE	-0,038 (0,120)	-0,060** (0,048)	0,031* (0,094)	0,013 (0,674)
ServVA	-0,064 (0,350)	0,177* (0,094)	0,134** (0,013)	-0,282*** (0,007)
ADR	0,082 (0,168)	0,142 (0,180)	0,010 (0,909)	0,387*** (0,000)
Observations	513	513	1 024	1 024
Countries	31	31	69	69
R-squared	0,734	0,844	0,231	0,707
Adjusted R-squared	0,717	0,834	0,208	0,698
Significance F	<0,001	<0,001	<0,001	<0,001

Note: p-values are reported in parentheses. All regressions include country and year fixed effects. P-values are based on country-clustered robust standard errors. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

Source: authors' calculations

The results show that ICT-related variables are associated differently with employment and labour productivity in advanced economies. ICT services exports are positively and statistically significantly associated with employment ((0,011), (p<0,05)). This suggests that stronger ICT services export intensity may support employment in high-value and knowledge-intensive activities, including software development, professional services, and digital business services.

Internet use also has a positive and highly significant association with employment ((0,061), (p<0,01)). Broader Internet diffusion may facilitate access to digital jobs, remote work, online services, platform-based activities, and more flexible forms of employment. The stronger statistical significance of IntUser suggests that domestic digital diffusion may be more closely associated with employment than external ICT services trade.

By contrast, ICT services imports are not significantly associated with employment ((0,013), (p=0,143)). Imported ICT services may support existing production and service processes without necessarily generating additional domestic employment.

The results differ for labour productivity. ICTExport, ICTImport, and IntUser are all statistically insignificant in the GDPpPE model, with coefficients of (-0,001), (-0,012), and (0.004), respectively. Thus, after controlling for country and year effects and other macroeconomic, institutional, structural, and demographic factors, ICT services trade and Internet use show no statistically confirmed association with labour productivity in advanced economies.

Instead, labour productivity is more strongly associated with broader economic and structural factors. GDP per capita ((=0,434), (p<0,01)) and trade openness ((=0,153), (p<0,01)) are positively associated with productivity. CPI is also positive and significant, while gross capital formation and tertiary education have negative and statistically significant coefficients. These findings suggest that productivity variation in advanced economies is more closely related to income levels, openness, macroeconomic conditions, and structural characteristics than to ICT-related variables alone. One possible explanation is that advanced economies have reached relatively high levels of digital maturity, so further increases in ICT services trade or Internet use do not automatically produce measurable productivity gains.

The results for developing economies reveal a distinct pattern. ICT services exports and imports are not statistically significant in the employment model. The coefficients for ICTExport and ICTImport are 0,013 and 0,005, respectively, with (p>0,10) in both cases. Unlike advanced economies, developing economies therefore show no significant association between ICT services trade and employment. This may reflect weaker absorptive capacity, limited participation in high-value ICT services, less developed digital ecosystems, and a larger share of informal or low-productivity employment.

Internet use, by contrast, is negatively associated with employment in developing economies ((=-0,021), (p<0,05)). This result should not be interpreted as evidence that Internet use directly reduces employment. Rather, digital diffusion may accompany labour-market restructuring through automation, sectoral reallocation, changes in informal employment, and a shift from low-skilled to more digitally intensive activities. The negative short- and medium-term association may therefore coexist with longer-term structural transformation.

The control variables support this interpretation. Tertiary education is positively and weakly associated with employment ((0,031), (p<0,10)), while services value added has a positive and statistically significant coefficient ((0,134), (p<0,05)). This suggests that the employment effects of digitalisation depend partly on complementary conditions, particularly human capital and economic structure.

For labour productivity, Internet use has a positive and statistically significant coefficient ((0,030), (p<0,05)). Combined with its negative employment coefficient, this finding suggests that digital adoption in developing economies is more closely associated with productivity-enhancing transformation than with immediate employment expansion. Internet diffusion may improve access to information, reduce transaction costs, increase business efficiency, and facilitate technology diffusion without proportionally increasing total employment.

ICTExport and ICTImport remain statistically insignificant in the productivity model, with coefficients of (-0,023) and (-0,016), respectively. This may indicate that ICT services trade remains too limited or concentrated in activities that do not yet generate economy-wide productivity gains.

Several control variables are significant. GDP per capita ((0,327), (p<0,05)) and political stability ((0,051), (p<0,05)) are positively associated with labour productivity. The age dependency ratio also has a positive and highly significant coefficient ((0,387), (p<0,01)), while services value added is negatively associated with productivity ((-0,282), (p<0,01)). The latter result may reflect the predominance of low-productivity, informal, or labour-intensive services in some developing economies.

The comparison between country groups highlights important differences. In advanced economies, ICT services exports and Internet use are positively associated with employment. In developing economies, ICT services trade is not significantly related to either outcome, while Internet use is negatively associated with employment and positively associated with productivity. Digitalisation therefore appears to operate through different channels depending on the level of development.

Pooled OLS and random-effects models were estimated as auxiliary specifications. The pooled results are less stable and partly reflect between-country differences, while the random-effects estimates broadly confirm the main Internet-use relationships. Nevertheless, the Hausman diagnostics support fixed effects as the preferred baseline specification.

Overall, the findings show that ICT services exports, ICT services imports, and Internet use capture different dimensions of digital transformation. ICTExport is relevant primarily for employment in advanced economies, ICTImport is insignificant across the baseline models, and Internet use is the most consistent ICT-related variable. Its relationship, however, varies across country groups and outcomes, supporting the separate analysis of advanced and developing economies.

4.3. ROBUSTNESS CHECK

To assess the stability of the baseline fixed-effects results, two additional specifications were estimated (Table 7). First, the models were re-estimated without GDP per capita, since GDPpC is a broad development indicator that may overlap with Internet use, tertiary education, capital formation, and services value added. Second, the main ICT-related variables-ICTExport, ICTImport, and IntUser were introduced with a one-year lag, while the control variables remained contemporaneous. This specification tests whether ICT-related factors affect employment and labour productivity with a delay.

The results without GDPpC confirm the main baseline findings. In the advanced-economy employment model, ICTExport remains positive and statistically significant ((0,014), ($p<0,05$)), indicating that its relationship with employment is not driven by the inclusion of GDP per capita. IntUser also remains positive and highly significant ((0,080), ($p<0,01$)), confirming the stability of the association between Internet diffusion and employment in advanced economies.

For developing economies, IntUser remains negatively associated with employment ((0,024), ($p<0,05$)), showing that this relationship is also robust to the exclusion of GDPpC. At the same time, Internet use remains positively associated with labour productivity, although the coefficient is significant only at the 10% level ((0,024), ($p<0,10$)). Overall, these results reinforce the view that Internet diffusion in developing economies is more closely linked to productivity-enhancing structural transformation than to immediate employment growth.

Table 7. Robustness checks, fixed effects results, 2006-2024

Variable	Adv. EMPL Without GDPpC	Adv. EMPL Lag 1	Adv. GDPpPE Without GDPpC	Adv. GDPpPE Lag 1	Dev. EMPL Without GDPpC	Dev. EMPL Lag 1	Dev. GDPpPE Without GDPpC	Dev. GDPpPE Lag 1
ICTExport	0,014** (0,029)	0,008 (0,213)	0,005 (0,584)	-0,008 (0,276)	0,020 (0,248)	0,012 (0,571)	-0,007 (0,730)	-0,036 (0,147)
ICTImport	0,005 (0,511)	0,011 (0,217)	-0,028** (0,047)	-0,013 (0,226)	0,007 (0,580)	0,005 (0,697)	-0,012 (0,590)	-0,014 (0,530)
IntUser	0,080*** (0,000)	0,057*** (0,006)	0,044 (0,439)	-0,002 (0,965)	-0,024** (0,031)	-0,020** (0,029)	0,024* (0,058)	0,034** (0,020)
GDP	0,146*** (0,000)	-0,071 (0,286)	0,267*** (0,000)	-0,138 (0,147)	0,066*** (0,005)	-0,070 (0,497)	0,287*** (0,000)	-0,103 (0,520)
GDPpC	—	0,221*** (0,000)	—	0,429*** (0,000)	—	0,136 (0,172)	—	0,375** (0,019)
CPI	0,007** (0,016)	0,007*** (0,005)	0,011*** (0,005)	0,011*** (0,001)	0,003 (0,170)	0,003 (0,265)	-0,002 (0,759)	-0,003 (0,615)
TO	0,123*** (0,000)	0,097*** (0,000)	0,218*** (0,000)	0,167*** (0,000)	0,017 (0,264)	0,012 (0,449)	-0,015 (0,626)	-0,026 (0,335)
PS	0,019* (0,095)	0,012 (0,277)	0,021 (0,357)	0,005 (0,800)	0,002 (0,886)	-0,005 (0,678)	0,063** (0,010)	0,051** (0,043)
GCF	0,085*** (0,000)	0,091*** (0,000)	-0,054** (0,035)	-0,046* (0,078)	0,013 (0,495)	0,018 (0,397)	0,037 (0,226)	0,053* (0,054)
SE	-0,062** (0,033)	-0,036 (0,166)	-0,111** (0,020)	-0,057* (0,070)	0,019 (0,336)	0,029 (0,125)	-0,013 (0,657)	0,015 (0,631)
ServVA	-0,109 (0,130)	-0,054 (0,363)	0,081 (0,588)	0,165 (0,117)	0,137*** (0,008)	0,143*** (0,008)	-0,276** (0,010)	-0,278*** (0,008)
ADR	0,156** (0,012)	0,087 (0,129)	0,296** (0,030)	0,144 (0,168)	0,094 (0,313)	0,028 (0,749)	0,566*** (0,000)	0,370*** (0,001)
Observations	513	506	513	506	1 024	1 010	1 024	1 010
Countries	31	31	31	31	69	69	69	69
R-squared	0,710	0,738	0,813	0,844	0,210	0,226	0,692	0,709
Adjusted R-squared	0,693	0,722	0,802	0,834	0,187	0,203	0,683	0,700
Significance F	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001	<0,001

Note: p-values are reported in parentheses. All regressions include country and year fixed effects. P-values are based on country-clustered robust standard errors. ***, ** *and * denote significance at the 1%, 5% and 10% levels, respectively.*

Source: authors' calculations

After GDPpC is excluded, ICTImport becomes negative and statistically significant in the advanced-economy productivity model ((-0,028), (p<0,05)). Because this relationship is not significant in the baseline specification, it should be interpreted cautiously. The result suggests sensitivity to the inclusion of broad development-level controls but does not provide sufficiently robust evidence for a central conclusion.

The one-year lag specification provides further insight into the timing of the estimated relationships. In advanced economies, lagged Internet use remains positively associated with employment ((0,057), (p<0,01)), indicating that the relationship persists with a one-year delay. By contrast, lagged ICT services exports and imports are not statistically significant.

In developing economies, lagged Internet use remains negatively associated with employment ((-0,020), (0,05)) and positively associated with labour productivity ((0,034), (p<0,05)). These results reinforce the interpretation that Internet diffusion is associated with labour-market restructuring and productivity-enhancing transformation rather than immediate employment expansion.

Lagged ICTExport and ICTImport are insignificant in most specifications, indicating no stable delayed relationship with either employment or labour productivity. Overall, the robustness analysis confirms Internet use as the most consistent ICT-related variable, while ICT services exports show a narrower association, primarily with employment in advanced economies.

5. DISCUSSION

The findings show that ICT services exports, ICT services imports, and Internet use are associated with employment and labour productivity in different ways across advanced and developing economies. Digitalisation should therefore not be treated as a homogeneous process. Its economic effects depend on the level of development, absorptive capacity, sectoral structure, institutional conditions, and the specific ICT indicator considered (Cardona et al., 2013; Jorgenson & Vu, 2016; OECD, 2019).

In advanced economies, ICT services exports are positively associated with employment. The coefficient is 0,011 (($p<0,05$)) in the baseline fixed-effects model and 0,014 (($p<0,05$)) in the specification excluding GDP per capita. This suggests that stronger participation in ICT services exports is linked to better employment outcomes. Advanced economies may be better able to convert ICT export activity into jobs in software, professional services, digital business activities, and other knowledge-intensive sectors. This interpretation is consistent with research emphasising the importance of digital capabilities and service-sector development (Freund & Weinhold, 2002; Choi, 2010; Borowiecki et al., 2021; Nucci et al., 2023).

Internet use also shows a stable positive association with employment in advanced economies. The coefficient is 0,061 (($p<0,01$)) in the baseline model, 0,080 (($p<0,01$)) when GDP per capita is excluded, and 0,057 (($p<0,01$)) in the one-year lag specification. Broader Internet diffusion may support labour-market participation through remote work, platform-based activity, digital services, and the expansion of ICT-enabled occupations. These findings are consistent with the view that digitalisation supports employment more effectively when combined with skills, institutional quality, and mature service-sector conditions (OECD, 2019; World Bank, 2023; Nayyar et al., 2024).

By contrast, ICT-related variables do not show a stable association with labour productivity in advanced economies. ICT services exports, ICT services imports, and Internet use are statistically insignificant in the baseline productivity model. One possible explanation is that advanced economies have reached relatively high levels of digital maturity, limiting the measurable productivity effects of further increases in ICT trade or Internet diffusion. Productivity in this group appears to depend more strongly on broader macroeconomic and structural conditions, including income levels, trade openness, capital formation, education, and sectoral composition. This is consistent with evidence that ICT-related productivity gains depend on complementary organisational, institutional, and human-capital capabilities (Cardona et al., 2013; Gal et al., 2019; Borowiecki et al., 2021).

For developing economies, ICT services exports and imports are not significantly associated with either employment or labour productivity. This suggests that ICT services trade has not yet generated broad and stable economy-wide effects in this group. Possible explanations include limited participation in high-value ICT services, weaker absorptive capacity, and greater dependence on education, institutions, demographic conditions, and sectoral structure. Previous studies similarly show that the benefits of digitalisation in developing economies depend on domestic capabilities and the wider business environment (Papaioannou & Dimelis, 2007; Peña et al., 2020; Oliinyk et al., 2024).

Internet use is the most important ICT-related variable in developing economies. It is negatively associated with employment in the baseline model ((-0,021), ($p<0,05$)), and this relationship remains stable when GDP per capita is excluded and when Internet use is lagged by one year. This should not be interpreted as evidence that Internet diffusion directly reduces employment. A more cautious interpretation is that digital adoption accompanies labour-market restructuring through automation, sectoral reallocation, changes in informal employment, and shifts from routine to more digitally intensive tasks. This interpretation is consistent with the literature showing that technological change may simultaneously displace some forms of labour and create others (Acemoglu & Restrepo, 2019; Goaied & Sassi, 2019).

At the same time, Internet use is positively associated with labour productivity in developing economies. The coefficient is 0,030 (($p<0,05$)) in the baseline model and 0,034 (($p<0,05$)) in the one-year lag specification. Internet diffusion may therefore support productivity-enhancing transformation by improving access to information, lowering transaction costs, strengthening business efficiency, and facilitating digital service delivery. However, these gains may occur alongside employment restructuring rather than immediate employment expansion. This finding is consistent with evidence that digital adoption can improve productivity while producing uneven labour-market effects (Peña et al., 2020; Nayyar et al., 2024; UNCTAD, 2024).

Overall, the results reveal distinct development patterns. In advanced economies, ICT services exports and Internet use are positively associated with employment. In developing economies, Internet use is associated with higher labour productivity but lower employment, which may reflect structural transformation. ICT services imports do not show a robust relationship with either outcome. These findings confirm the importance of analysing ICT services trade and domestic digital adoption separately (World Bank, 2016; World Bank, 2023; UNCTAD, 2024).

The estimates should be interpreted as conditional associations rather than causal effects. Although country and year fixed effects, country-clustered robust standard errors, and lagged specifications improve the reliability of the analysis, endogeneity cannot be fully eliminated. ICT services trade, Internet use, productivity, employment, and income may be jointly determined. The results therefore identify statistically significant relationships, not direct causal impacts. This caution is consistent with previous research emphasising the sensitivity of ICT estimates to measurement, model specification, and country context (Cardona et al., 2013; Niebel, 2018; Nayyar et al., 2024).

From a policy perspective, the findings suggest that digital strategies should differ across country groups. Advanced economies may benefit from policies that strengthen ICT services export capacity and digital labour-market participation. Developing economies should combine Internet expansion with investment in skills, business upgrading, productive employment, and institutional capacity. Without these complementary conditions, digitalisation may raise productivity while contributing to labour-market restructuring rather than broad employment growth (OECD, 2019; World Bank, 2016; UNCTAD, 2024).

6. CONCLUSION

This article examined the relationship between ICT services trade, Internet use, employment, and labour productivity in advanced and developing economies over the period 2006–2024. The analysis applied fixed-effects panel models with country and year effects, country-clustered robust standard errors, and inverse hyperbolic sine transformations. Countries were classified according to the IMF World Economic Outlook.

The findings show that ICT services exports, ICT services imports, and Internet use are associated differently with labour-market and productivity outcomes. These indicators should therefore not be treated as interchangeable measures of digitalisation. ICT services exports capture external digital competitiveness, ICT services imports reflect reliance on foreign digital inputs, and Internet use represents domestic digital diffusion. In advanced economies, ICT services exports and Internet use are positively associated with employment. These relationships remain stable in the robustness specifications, suggesting that advanced economies are better positioned to translate digital competitiveness and Internet diffusion into employment opportunities, particularly in knowledge-intensive and digitally enabled activities.

By contrast, ICT-related variables do not show a stable relationship with labour productivity in advanced economies. Productivity appears to depend more strongly on broader structural and macroeconomic conditions, including income levels, trade openness, capital formation, education, and sectoral characteristics. This may also reflect digital maturity, whereby further increases in ICT services trade or Internet use generate limited additional productivity gains. Developing economies display a different pattern. ICT services exports and imports are not significantly associated with either employment or labour productivity. Their limited role may reflect weaker integration into high-value ICT services, lower absorptive capacity, and greater dependence on institutional, educational, and structural conditions. Internet use is the most important ICT-related variable in developing economies. It is negatively associated with employment but positively associated with labour productivity, and this pattern remains broadly stable across the robustness checks. These results should not be interpreted as evidence that Internet diffusion directly reduces employment. Rather, they suggest that digital adoption may support productivity-enhancing transformation while contributing to labour-market restructuring, sectoral reallocation, and changes in the composition of employment.

The robustness analysis confirms the main findings. Excluding GDP per capita does not alter the principal employment results for advanced economies or the main Internet-use relationships for developing economies. The one-year lag specification also confirms Internet use as the most stable ICT-related variable. ICT services imports, in contrast, do not show a robust association with either outcome. The study has several limitations. The estimates identify conditional associations rather than causal effects, since ICT services trade, Internet use, productivity, and employment may be jointly determined. The use of country-level data also prevents the identification of firm-level and sector-specific mechanisms. In addition, developing economies form a highly heterogeneous group.

Future research could distinguish between income groups, regions, and forms of digital specialisation, while also applying dynamic panel models, instrumental-variable methods, or sector-level data. The policy implications differ across country groups. Advanced economies may strengthen employment by supporting ICT services exports, digital business ecosystems, and Internet-enabled labour-market participation. Developing economies should combine Internet expansion with investment in skills, business upgrading, institutional capacity, and productive employment. Without these complementary conditions, digitalisation may raise productivity while intensifying labour-market restructuring rather than generating broad employment growth.

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