Digitalization and Productivity in Asia and the Pacific

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Abstract

Digitalization induces structural change by improving labor productivity. High levels of digitalization shield productivity from adverse shocks. This study shows that on average digitalization increases labour productivity. These impacts are larger and significant for developed countries than for developing countries. Furthermore, heterogeneous effects are observed across geographical regions and economic development levels. In particular, Asia-Pacific countries show increased productivity while no significant impacts are observed in Africa and Latin America and the Caribbean countries. Across income levels, only high income and upper-middle income developing countries have registered increasing labour productivity levels. Digitalization influences labour productivity through various channels. Increased labour compensation, productive government expenditures and complementary investments are main drivers of labour productivity. However, increased intensity in government restrictions to pandemic has significant adverse impact on labour productivity. Digital inclusion in terms of availability, affordability, relevance and readiness increases labour productivity in the Asia-Pacific region. However, policy measures that ensure improvements in all four domains are desired to harness the full benefits of digitalization in developing countries.

Key words: Digitalization; Digital inclusion; Availability; Affordability; Relevance; Readiness; Pandemic

1. Introduction

Digitalization drives economic growth by stimulating labour productivity (Brussevich, et al., 2018; Anghel B. B., 2024). Technological advancements are a major source of productivity improvement. Digital technologies generate productivity gains by altering production processes, improving complementarity between labour and capital and increasing automation (Anghel B. B., 2024). As a result, the structure and the work task composition of occupations are changing (Deschacht, 2021; Ivanov, Kuyumdzhiev, & Webster, 2020). These occupational changes influence labour market outcomes: wages, inequality, job quality and unemployment. Despite the boom and optimism toward digitalization, productivity has stagnated or slowed down in both advanced and emerging economies (Acemoglu, et al., 2014; Mollins & Taskin, 2023).

Lack of gain in productivity, compared to substantial improvements in digital technologies is considered a productivity paradox (Goldin, et al., 2024). The productivity slowdown is due to multiple factors. The new digital economy is strictly depend on information communication technology (ICT) services and knowledge products (Van Ark, 2016). The expected productivity gains are therefore, possible only after a period of maturity of these technologies. Innovation is critical for boosting productivity, especially in the large firms (Tang & Wang, 2004). When less productive firms remain in the market, it drags down productivity (Decker, et al., 2017). In the manufacturing sector, difficulties in natural resource extraction and the underutilization of technical capacity are considered primary factors of productivity decline (Gu & Willox, 2018). In comparison to the early years of adoption, digitalization is no longer effective in driving productivity in advanced economies (Balsmeier & Woerter, 2019). Some argued that the current scenario is not a decline but, rather a return to normalcy following an exponential growth (Fernald, 2015).

Despite the claims on productivity slow down, digital technology has the potential to stimulate productivity improvements and long-term growth. The application of new technologies depends on the investment in intangible assets like human capital, new processes and organisational structures (Brynjolfsson, Rock, & Syverson, 2019). The gains, however, not distributed in an equitable manner. This inequality can increase disparities in productivity at firm level, thus, can negatively impact on aggregate productivity growth. Developing countries are falling behind on digital transformation as most countries show limited digital adoption. In 2022, nearly 90% of population in developed countries uses internet while this is only 50% in developing countries (EIU, 2024). During the COVID-19 pandemic, the risk of being digitally excluded has been increasingly highlighted. Hence, digital-led bigger boost to productivity is still anticipated in developing countries. Widening digital divide reduces prospects for digital-led productivity growth. Hence, digital inclusion is critical to realize sustainable increase in digital-led productivity growth (Adam & Dzang, 2021). Digital inclusion is defined as “both inclusive ICT and the use of ICT to achieve broader social inclusion objectives, and thus, it is about both inclusive technological innovation and innovative ways to deliver inclusive policies by using ICT” (Codagnone, 2022).

Digitalization and its labour market impacts vary significantly across countries. Understanding cross-country differences in digital-led productivity is urgent and important to propose corrective measures. The association between digitalization and productivity is however,

under-researched in developing countries. Therefore, this study fills this gap by exploring the link between digital inclusion and labour productivity in developing countries. This study significantly contributes to the literature by answering the research question, 'what is the impact of digital inclusion on labour productivity in developing countries'. The main aims of the study are to investigate the association between digital inclusion and labour productivity and to identify the channels through which the digital inclusion drives productivity.

This study shows that digital inclusion has significant impact on labor productivity in Asia-Pacific region, but not for Africa and Latin America and the Caribbean regions. This is no surprise as Asia-Pacific has the best digital inclusion scores among developing countries. The magnitude of the impact is however, quite smaller. The disaggregated analysis on digital inclusion index for Asia-Pacific region shows that all four domains: availability, affordability, relevance and readiness are increasing labour productivity. However, policy support in improving each domain is expected to obtain maximum benefits of digitalization for developing economies.

The remainder of the study is organised as follows. Section 2 presents the review of literature and Section 3 describes the methodology. Section 4 contains the results and discussion. Section 5 concludes.

2. Labour Productivity and Digitalization

Structural change is a critical determinant of labour productivity. Development involves structural change (McMillan, Rodrik, & Verduzco-Gallo, 2014). Countries develop when economies are diversified by the movement of labour from traditional sectors to modern economic activities. The speed of this structural transformation is the key for development success. Productivity gaps in firms and sectors are larger in developing countries than in developed countries. On average, labour productivity in developing countries is less than one-fifth of that in advanced countries (Kindberg-Hanlon & Okou, 2020). This is an indicative of resource allocation inefficiencies in a country. Economies grow when labour move from less productive to more productive activities. Differences in growth is explained by the variation in the contribution of structural change to overall productivity. Globalization is facilitating technology transfer to developing countries. When countries are more integrated, high productivity employment leads to structural change and growth eg: China and India. However, when labour moved from high to low productive activities, growth is not achieved eg: African and Latin American countries.

Technological progress is a primary source of productivity that ensures economic growth and well-being (Papanyan, 2015). The world experienced three industrial revolutions: steam power and mechanization, electricity and fossil fuel energy and adoption of ICT. The fourth revolution is digitalization which is considered as the fundamental driver of current and future productivity growth. However, the productivity slowdown is undeniable (Syverson, 2017). Regardless of the rapid increase in digitalization, sluggish productivity growth rates have led to a 'productivity puzzle'. Understanding the channels of impact at both macro and micro levels is vital to propose corrective measures.

Historical context. The post-pandemic slowdown in productivity is explained relative to pre-pandemic productivity. The 20th century productivity growth is attributable to post-war boom and ICT (Bergeaud, Cette, & Lecat, 2016). During 1948-1973, the post-war growth has driven by capital deepening and innovations like electrification. ICT driven productivity growth is resultant from improvements in the production processes. Comparatively, the post-pandemic labour productivity growth rates in almost all countries are lower than to the pre-pandemic rates. Amidst increasing technological transformation driven by ICT, this slowdown however, appears surprising.

Digital adoption. Labour productivity decelerates when there is uneven adoption and diffusion of digital tools (Calvino & Criscuolo, 2019). The access to any digital tool does not ensure increased growth. Firms with access to productivity enhancing digital tools experience productivity enhancements as oppose to the firms accessing only high-speed broadband networks. For instance, the operational efficiency is higher in firms using 'enterprise resource planning systems' due to automation of routine tasks, improved data accuracy and well-organized tasks and processes. Digital transformation depends on complementary investments in process innovation, new system and business models (Mollins & Taskin, 2023). Further, the accuracy of practical implementation determines firms' long-term existence. Therefore, number of firms that enter and exit is different and this leads to substantial variations in digital adoption across countries.

Productivity mismeasurement. In many advanced economies, measurement problems have underestimated the productivity gains resulting from digitalisation (Ahmad, Ribarsky, & Reinsdorf, 2017). This has raised concerns over adequacy of the existing compilation methods to understand the contribution of digitalisation to GDP and other macroeconomic indicators. Digitalisation has not sufficiently captured in the existing classification systems in estimating economic activities. Thus, the impacts of digitalization on economy may be miscalculated.

Lags between implementation and usage. Digitalization needs time to materialize and deliver productivity improvements (Anghel B. , et al., 2024). There are few requirements for the success of digitalization: development of new physical and organisational structure and skills. These pre-conditions are liable on institutional and country capacities. Therefore, variations in digitalization is unavoidable.

At macro-level, the digitalization effects on labour productivity is decomposed into growth in total factor productivity (TFP) and rate of the capital/labour ratio (capital deepening). TFP growth is conditional on the type of industry (Wolff, 1991). Innovations improve TFP growth in ICT-producing sectors. However, as these firms share in total economy is small, productivity gains are limited. The diffusion effect (network effect) drives TFP growth in ICT-using sectors. The new communication technologies affect positively on a larger share of firms because of the decreased communication costs. This diffusion effect has a definite impact on skills. Firms preference to hire more of a particular skill however, can create suboptimal situations by creating an abundance of skills that are not required in future productivity gains. Capital deepening impacts TFP growth when price of capital equipment reduces due to technology advancements. Therefore, with increased digitalization, ICT-adopting firms increase capital/labour ratio.

At firm level, technological advancements can help increasing worker efficiency by complementing their tasks and outsourcing the non-core occupations (Gal, et al., 2019; Bergeaud, et al., 2021). The impact of digital technologies through market channel has also recognized. Firms' productivity enhanced via qucik growth and economies of scale, e-commerce increases competitiveness and market share and allowing access to a wide-variety of imported goods (Albani, Anyfantaki, & Lazaretou, 2019; Malgouyres, Mayer, & Mazet-Sonilhac, 2021).

During the pandemic, digitalization played a critical role (Mollins & Taskin, 2023). Relatively, the digitally-intensive firms with pre-exising digital technologies performed better than other firms during the pandemic. The opportunity to working from home triggers strong productivity growth. The IT service providers however, face difficulties due to increased demand. The long-term impacts of digitalization is fundamentally determined by the firms' organizational capital and availability of digital assests.

3. Methodology

Pandemic induced digitalization has long lasting implications on productivity and labour markets (Jaumotte, et al., 2023). Higher digital adoption improves productivity, yet, poor adoption leads to inequalities. The empirical evidence on the impacts of pandemic induced digitalization on labour productivity is scarce for developing economies. Hence, this study investigates the nexus between digitalization and labour productivity in developing countries.

3.1 Data

The empirical analysis uses a balanced panel of 96 countries covering the period 2017-2022. This includes 25 developed economies and 71 developing economies in Africa (30), Asia-Pacific (25) and Latin America and the Caribbean (16) regions. (Table 1A in the Appendix provides a list of all countries). The outcome variable is labour productivity measured by the level (output per hour worked) and growth rate (annual growth rate of output per worker). These data obtained from the International Labour Organization (ILO, 2024).

Digitalization is measured using the inclusive internet index of the 'Economist Impact' web platform (Jahan & Zhou, 2023; EI, 2024). The index scores ranged from 0 to 100, where 100 means most inclusive internet environment. The overall index score consists of four domains: availability (quality and breadth of infrastructure and internet usage); affordability (access cost and market competition); relevance (Local and relevant content) and readiness (capacity to access including skills, culture, policy). Each main domain contains several sub-domains as indicated in Table 2A in the Appendix). Variations in digital inclusion rates create differences in labour productivity across countries.

The stringency index of the Oxford Covid-19 government response tracker is used to analyse the impact of pandemic on labour productivity (Jahan & Zhou, 2023; OxCGRT, 2024). This variable explains the pandemic related policy measures implemented by various governments. This is a composite measure which constructed on daily data on nine mobility restriction indicators: school closures, workplace closures, public event cancellations, public gathering restrictions, public transport closures, stay-at-home requirements, public

information campaigns, restrictions on internal movements and international travel controls. This index is measured on a scale 0-100, where 0 means less stringent and 100 means the most stringent. Labour productivity increased at the outset of the pandemic, but, decelerates later. Digital uptake increases productivity within-firm as it helps adjust to remote working (Borowiecki, et al., 2021). Yet, destruction of jobs and lower human capital accumulation due to disturbances to education impact negatively on labour productivity.

The study uses several other control variables considering the theoretical explanations on labour productivity: employed labour force, human capital index, labour compensation share in the GDP, gross fixed capital formation and the government expenditure (Banday & Erdem, 2024). These data extracted from the World Development Indicators of the World Bank, Our World in Data Web platform and the IMF (WDI, 2024; OWID, 2024; IMF, 2024).

The employed labour force indicates the strength of labour supply in a country (Dua & Garg, 2019). It is proxied using the labour force participation rate which measures the percentage of working age population that is actively participating in the labour market. Increased labour participation triggers higher productivity and results in increased outputs. Labour shortages decrease competitiveness, thus, counterproductive for labour productivity (Samargandi, 2018). Digitalization can reduce labour share in the value of output and generates new opportunities for employment leading to better economic and social outcomes (Acemoglu & Restrepo, 2022). The automation in manufacturing sector leads to job losses but, this is often balanced with the new jobs created in the services sector (Dauth, et al., 2021).

Human capital is a primary determinant that associates positively with labour productivity (Samargandi, 2018). It encompasses contributions of health and education to worker productivity (WDI, 2024). The final index score ranges between 0 to 1. The score of 1 means if a child born today can expect to achieve full health (defined as no stunting and survival up to at least age 60) and achieve her formal education potential (defined as 14 years of high-quality school by age 18). Therefore, the index measures the productivity as a future worker of child born today relative to the benchmark of full health and complete education. Availability of knowledge and innovation enhances the impacts of human capital. Thus, education and health has substantial impact on human capital (Abdelgany & Saleh, 2022). To boost human capital, education policy plays a critical role (Quiggin, 1999). This mainly includes policies encouraging high investments for early childhood education and for lowering pupil-teacher ratio.

Labour compensation share in the GDP is an indicative of the efficiency of labour. Labour compensation and productivity growth can decouple (Kapeliushnikov, 2015; Meloni & Stirati, 2023). In addition to direct labour compensation costs, firms may face other indirect costs like contributions to social funds and other hidden payments to workers. During a crisis, labour compensation in GDP tend to increase than the growth in labour productivity. Public policies and institutions are important factors of the link between labour productivity and labour compensation. Investment in skills ensure gains from technological advancements. Because, when technology is cheaper, capital is difficult to substitute by high-skill workers.

The gross fixed capital formation or investment is a main determinant of labour productivity (Acemoglu, 2003). Capital deepening or the increased use of capital relative to labour

increases labour productivity. It directly impacts by providing more resources to workers and indirectly by contributing to changes in working practices. As a result, demand for labour and employment increases. Capital investments have significantly contracted during the pandemic.

Both the neoclassical and the standard New Keynesian models predict negative impact of government expenditure on labour productivity (Nekarda & Ramey, 2011). The link however, depends on the nature of expenditure. Increased government spending on environment and military expenditures reduce labour productivity in Europe (Fedotenkov & Gupta, 2021). In contrast, expenditure on public order and safety and lower corruption trigger positive impacts between government expenditure and labour productivity.

3.2 Empirical Strategy

The analysis on the association between pandemic induced digital inclusion on labour productivity closely follows the empirical model proposed by Banday & Erdem (2024) and Jahan & Zhou (2023). Accordingly, this study estimates the following model by employing panel fixed-effects (FE) and system generalized methods of moments (GMM) (Karacuka, Myovella, & Haucap, 2024):

$$Y_{it} = \beta_1 + \beta_2 digital_{it} + \beta_3 stringency_{it} + \beta_4 X'_{it} + \mu_i + \eta_t + \varepsilon_{it} \quad (1)$$

where the outcome variable, Y_{it}, is the natural logarithm of labour productivity for country i at time t. This includes two variables: output per hour worked (level) and annual growth rate of output per worker (growth). There are seven explanatory variables. The main explanatory variable of interest is $digital_{it}$, that measures digital inclusion using inclusive internet index of country i at time t. Then, $stringency_{it}$ denotes the intensity of government restrictions during the pandemic. The other control variables (X'_{it}) are the employed labour force, human capital index, labour compensation share in the GDP, gross fixed capital formation and the government expenditure. (Table 3A in the Appendix provides definitions of each variable).

The regression (1) is likely to suffer from omitted variable and endogeneity bias. The change in labour productivity may not be necessarily due to digital skills but due to other factors, thus, a number of control variables are used in the estimation. μ_i and η_t are country and year fixed effects, respectively. Country fixed effects control for unobserved influences that vary across countries (geography, culture etc.) and time fixed effects control for evolving unobserved national attributes that affect the likelihood of labour productivity (government policy reforms etc.). ε_{it} is the error term. The estimation uses 1,000 bootstrap replications to address the issue of autocorrelation.

In addition, to analyse the existence of potential interaction between the digital inclusion and the stringency index, an interaction term is added as follows (Jahan & Zhou, 2023):

$$Y_{it} = \beta_1 + \beta_2 digital_{it} + \beta_3 stringency_{it} + \beta_4 X'_{it} + \beta_5 digital_{it} * stringency_{it} + \mu_i + \eta_t + u_{it} \quad (2)$$

where $\beta_5 digital_{it} * stringency_{it}$ is the interaction term between the digital inclusion and the stringency index and u_{it} is a random error term.

4. Results and Discussion

The objective of this study is to evaluate the impact of digitalization on labour productivity by estimating the Equation (1) in Section 3.2. This section includes a detailed discussion on descriptive and empirical analyses. The empirical estimation begins with the full sample of 96 countries and subsequently investigates the impacts across development stage, geographic region and income.

4.1 Descriptive Analysis

Table 1 shows the summary statistics of all the variables. Table 4A in the Appendix provides summary statistics for five other sub-samples: developed, developing, Africa, Asia-Pacific and Latin America and the Caribbean. Then, Table 5A in the Appendix provides the correlation matrix. Accordingly, digital inclusion weakly correlates with labour productivity. Also, the labour compensation share in the GDP show weak correlation. In contrast, human capital index and the government expenditure show strong correlation to the labour productivity. Yet, stringency index, employed labour force and gross fixed capital formation show no correlation to the labour productivity.

Table 1: Summary Statistics, Full Sample

Variables	Mean	Std. Dev.	Min	Max	Observations
Outcome variable					
Labour productivity	26.805	24.057	1.32	141.64	576
Labour productivity growth	0.825	3.967	-20.477	21.333	576
Explanatory variables					
Digital inclusion	51.234	28.855	0.000	86.100	576
Stringency index	20.527	26.576	0.000	84.260	576
Labour force participation	68.149	10.439	40.726	89.623	576
Human capital index	0.560	0.168	0.000	0.887	576
Labour compensation	47.566	10.462	-2.680	70.600	576
Gross fixed capital formation	23.038	6.930	1.225	54.274	576
Government expenditure	30.460	12.205	7.340	69.200	576

Table 2 displays that amidst the post-pandemic increase in digitalization, labour productivity growth rates have declined across all countries, except the Latin America and the Caribbean region. The largest drop in productivity growth of 1.37% is observed for the Asia-Pacific region.

Table 2: Labour Productivity Slow Down

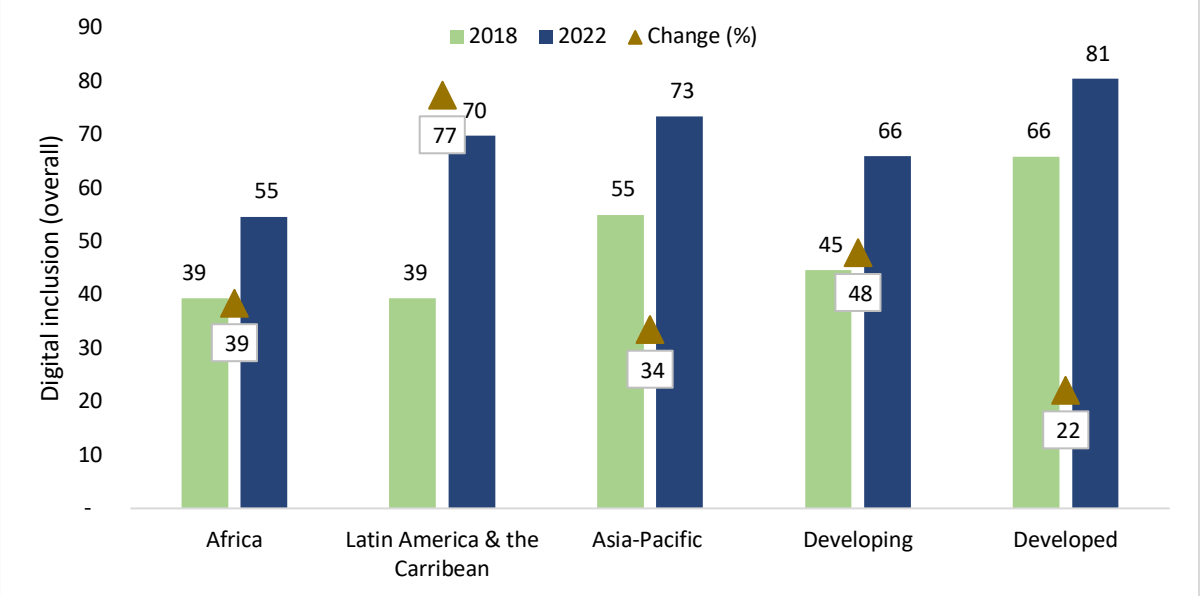
	Digital Inclusion (%)			Labour Productivity Growth (%)		
	2017-2018	2019-2022	Change (%)	2017-2018	2019-2022	Slow Down
Developed Countries	66	77	16	1.40	1.25	0.15

Developing Countries	45	61	36	1.24	0.36	0.88
Africa	39	51	29	1.35	0.13	1.22
Asia-Pacific	56	69	61	2.37	1.01	1.37
Latin America and the Caribbean	39	63	24	-0.72	-0.21	-0.52

Notes: Digitalization is indicated by digital inclusion (overall). Labour productivity slowdown is annual growth rate in output per hour worked.
Source: Inclusive Internet Index 2024. Economist Impact and ILOSTAT, International Labour Organisation 2024.

Figure 1 shows that developed countries has the highest pre-pandemic digital inclusion of 66% as oppose to 45% inclusion in developing countries in 2018. Among developing countries, the highest pre-pandemic inclusion of 55% is observed for the Asia-Pacific region whereas both Africa and Latin America and the Caribbean regions have only 39% of inclusion. Nevertheless, the Latin America and the Caribbean region increases inclusion by 77% and reached 70% inclusion in 2022. However, the rate of increase in inclusion for Africa, Asia-Pacific and developed countries are much lower and stood at 39%, 34% and 22%, respectively. Accordingly, the post-pandemic inclusion for each region stood at 55%, 73% and 81%, respectively. Figure 1A in the Appendix show the patterns of variation in all four domains from 2018-2022. Developed countries has the best scores for all four domains followed by Asia-Pacific, Latin America and the Caribbean and Africa. A similar pattern is observed for the internet users across each category (Figure 2A in the Appendix).

Figure 1: Digital Inclusion (Overall)

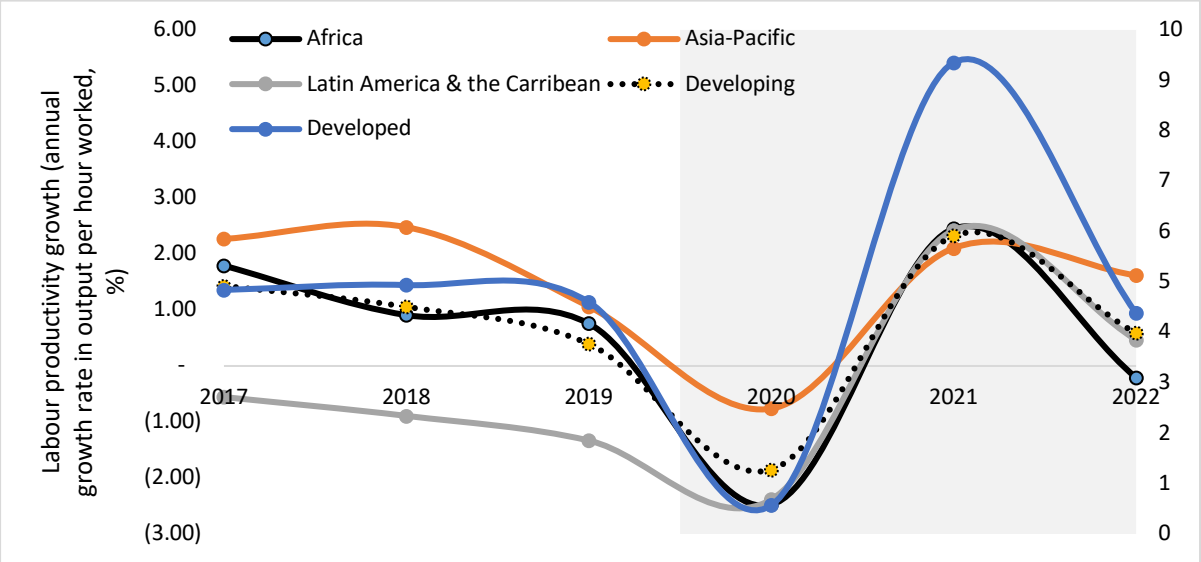


Source: Inclusive Internet Index 2024. Economist Impact.

Regardless of the increased digital adoption, post-pandemic labour productivity growth rates are deteriorating (Figure 2). Developing countries have experienced the largest productivity growth slowdown of 0.88 percentage points while developed countries are experiencing only 0.15 slowdown. However, Latin America and the Caribbean region is an exception. Unlike the other two regions, this region shows 0.52 percentage point increase in productivity growth. Accordingly, nine out of 16 countries in this region (i.e. >50%) show increase in productivity

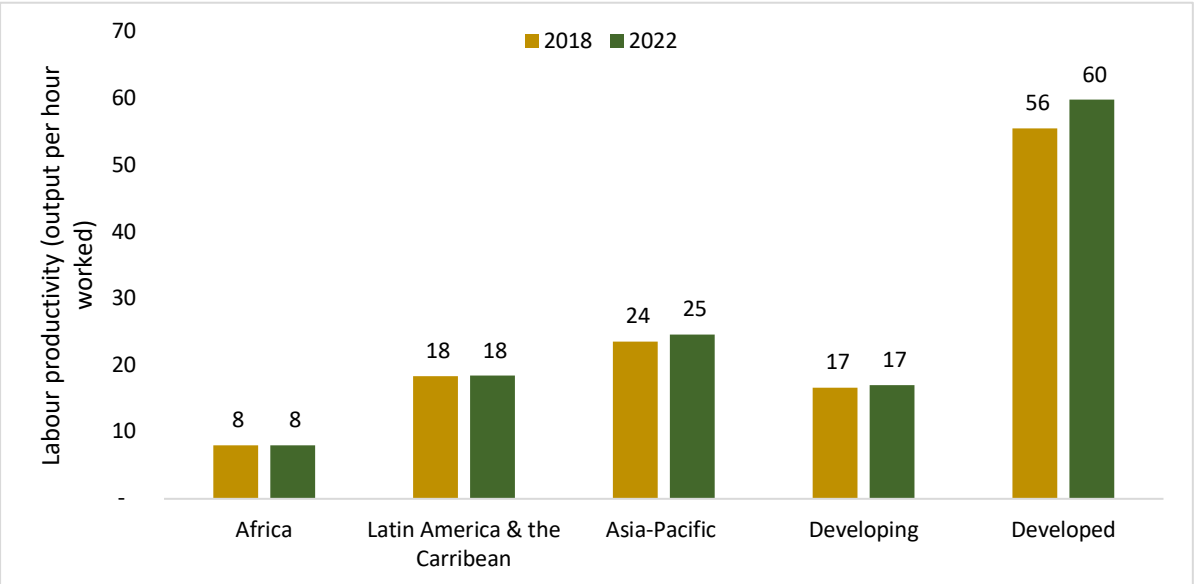
growth. Three countries with the largest productivity growth rates are the Venezuela (6.6%), Honduras (3.5%) and Colombia (2.0%). In contrast, labour productivity growth has declined in 17 out of 25 countries in the Asia-Pacific region (i.e. ≈70%). The three worst affected countries are the Lebanon (-9.6%), Sri Lanka (-8.0%) and Philippines (-6.4%). Labour productivity growth rates have weakened in all the East Asian countries and in a large majority of South Asian countries (i.e. 70%) while productivity growth rates in a majority of the West Asian countries have not affected. Three countries with the highest post-pandemic productivity growth rate are from West Asia: Kuwait (5.4%), Oman (4.8%) and Qatar (4.8%).

Figure 2: Labour Productivity Growth



Notes: Labour productivity slowdown is annual growth rate in output per hour worked (%).
Source: ILOSTAT, International Labour Organisation 2024

Figure 3: Labour Productivity (Output per Hour Worked)



Notes: Labor productivity is measured as the output produced per hour worked, GDP constant 2017 international USD1,000 at PPP
Source: ILOSTAT, International Labour Organisation 2024

Prior to the pandemic, developed countries own the highest labour productivity of USD 56 (output produced per hour worked) (Figure 3). This is nearly three times larger than that of developing countries (USD 17). After the pandemic, output produced per hour worked increased in almost all the countries. Yet again, developed countries with 8% productivity enhancement while developing countries show a much smaller increase of 2%. Among developing countries, the pre- and post- pandemic outputs are highest for the Asia-Pacific region (24% and 25%) while both Africa and Latin America and the Caribbean regions show stagnation.

4.2 Empirical Analysis

The purpose of this section is to estimate the impact of digital inclusion on labour productivity for the period 2017-2022. The estimation of the labour productivity closely follows Banday & Erdem (2024), Jahan & Zhou (2023) and Karacuka, Myovella, & Haucap (2024).

4.2.1 Digitalization Effect on Labour Productivity

During a crisis, it is common to observe decrease in labour productivity. Pandemic triggered workplace closures and lockdowns can have negative impact on labour productivity. Digitalization has proven to drive present and future growth (Aleksandrova, Truntsevsky, & Polutova, 2022; Sinha, Roy, & Tirtosuharto, 2024; Nguyen, 2024). Hence, increased digitalization is expected to neutralize these negative impacts. Despite substantial variations, pandemic has accelerated digitalization in most countries (Figure 1). In that scenario, improving digital adoption would help lessen the long-term negative impacts of the pandemic. Contrary to expectations, labour productivity remains stagnated in many countries (Figures 2 and 3). Hence, it is important to understand the causal relationship between digitalization and labour productivity to address the barriers and harness the maximum benefits of digitalization.

It is hypothesised that the digital inclusion has a significant positive impact on labour productivity during pandemic. Table 3 presents the estimates of digital inclusion on labour productivity by development stage i.e. for developed and developing countries. Columns (1) do not include the control variables, columns (2) include stringency index and the interaction term (Digital*Stringency) while columns (3) includes the interaction term and all six control variables: employed labour force, human capital index, labour compensation, gross fixed capital formation (investment) and government expenditure. The estimates of digital inclusion show positive impact on labour productivity. On average 1 unit increase in digital inclusion increases labour productivity by about USD 0.03. The interaction term suggests that positive impact of USD 0.08 and USD 0.02 exists for both developed and developing countries. Hence, the impact of digital inclusion is even more pronounced with the increase in magnitude of the stringency index (i.e. increased intensity of government policies during the pandemic). Stringency index seems to have negative and significant impact on labour productivity for developing countries. Accordingly, one-unit increase in stringency decreases labour productivity by USD 0.05.

Though not significant, employed labour force positively impacts on labour productivity while all other variables show negative impacts for developed countries. For developing countries, labour compensation and government spending show positive impacts. 1 unit increase in labour compensation increases labour productivity by USD 0.15. Increasing compensation associates with increases in productivity (Fuentes-Castro, 2012; Shakya & Plemmons, 2022). However, since 1970s, productivity and compensation show divergence. Labour compensation includes wages and other benefits. These impacts vary across sectors and industries. Manufacturing, information and retail trade show larger gaps compared to accommodation and food services.

Table 3: Estimates of Digital inclusion on Labour Productivity

	Developed Countries			**Developing Countries**		
	(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Outcome variable: Output per hour worked						
Digital inclusion	0.046***	0.035**	0.033*	0.008*	0.003	0.003
	(0.011)	(0.012)	(0.015)	(0.003)	(0.003)	(0.003)
Stringency index		-0.243	-0.104		-0.050***	-0.051***
		(0.178)	(0.254)		(0.011)	(0.011)
Digital*Stringency		0.003	0.002		0.001***	0.001***
		(0.002)	(0.003)		(0.000)	(0.000)
Employed labour force			0.711			-0.091
			(0.553)			(0.085)
Human capital index			-23.453			-0.569
			(25.555)			(11.777)
Labour compensation			-0.078			0.150
			(0.291)			(0.077)
Investment			-0.584			-0.004
			(0.621)			(0.031)
Government spending			-0.412			0.063
			(0.267)			(0.038)
R-squared	0.134	0.161	0.420	0.030	0.101	0.199
Outcome variable: Growth rate of output per worker						
Digital inclusion	0.001	-0.001	0.003	-0.012	-0.001	0.001
	(0.006)	(0.006)	(0.008)	(0.007)	(0.008)	(0.008)
Stringency index		-1.935***	-1.988***		-0.139**	-0.155***
		(0.298)	(0.327)		(0.048)	(0.046)
Digital*Stringency		0.024***	0.025***		0.002**	0.002**
		(0.004)	(0.004)		(0.001)	(0.001)
Employed labour force			-0.601			-0.454*
			(0.397)			(0.231)
Human capital index			-50.511			-11.560
			(29.639)			(24.765)
Labour compensation			0.022			-0.175
			(0.188)			(0.154)
Investment			-0.046			0.241**
			(0.234)			(0.075)
Government spending			-0.030			-0.140
			(0.185)			(0.085)
R-squared	0.0001	0.280	0.320	0.008	0.051	0.133
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Countries	25	25	25	71	71	71
Observations	150	150	150	426	426	426

Notes: Columns (1) do not include control variables while columns (2) and (3) do. Control variables include employed labour force (% of total population), human capital index (scores=0 to 1), labour compensation (% of GDP), gross fixed capital formation (% of GDP) and government expenditure (% of GDP). Robust standard errors in parentheses are bootstrapped with 1,000 replications. ***, **, and * indicate statistical significance at 1%, 5% and 10% nominal level, respectively.

4.2.2 Heterogeneous Digitalization Effects Across Regions

Digitalization on labour productivity has heterogeneous impacts across regions. Table 4 shows labour productivity estimates for developing countries in Africa, Asia-Pacific and Latin America and the Caribbean regions. Digital inclusion impacts are further decomposed into availability, affordability, relevance and readiness. It is clear that the digitalization effect on labour productivity varies across regions.

Table 4: Estimates of Digital Inclusion on Labour Productivity, by Region

	Africa		**Asia-Pacific**		**Latin America & Caribbean**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Outcome variable: Output per hour worked						
Digital inclusion	0.003	0.001	0.012*	0.010**	0.003	0.003
	(0.002)	(0.002)	(0.005)	(0.005)	(0.007)	(0.005)
Availability	0.005	0.003	0.013*	0.010*	0.006	0.002
	(0.003)	(0.003)	(0.005)	(0.005)	(0.008)	(0.006)
Affordability	0.002	0.001	0.009*	0.007	0.004	0.002
	(0.002)	(0.002)	(0.004)	(0.004)	(0.006)	(0.004)
Relevance	0.003	-0.001	0.014**	0.013**	0.005	0.004
	(0.002)	(0.003)	(0.005)	(0.005)	(0.007)	(0.005)
Readiness	0.002	0.001	0.015**	0.012*	0.008	0.003
	(0.002)	(0.002)	(0.005)	(0.005)	(0.007)	(0.006)
Outcome variable: Growth rate of output per worker						
Digital inclusion	-0.027*	-0.014	-0.012	-0.002	0.008	0.011
	(0.013)	(0.016)	(0.010)	(0.113)	(0.010)	(0.015)
Availability	-0.033*	-0.019	-0.013	-0.003	0.007	0.010
	(0.016)	(0.020)	(0.011)	(0.011)	(0.011)	(0.016)
Affordability	-0.020*	-0.012	-0.013	-0.003	0.004	0.007
	(0.009)	(0.011)	(0.009)	(0.009)	(0.009)	(0.013)
Relevance	-0.025	-0.009	0.008	0.004	0.017	0.020
	(0.014)	(0.017)	(0.010)	(0.011)	(0.012)	(0.017)
Readiness	-0.025	-0.009	-0.013	-0.002	0.004	0.009
	(0.014)	(0.016)	(0.011)	(0.012)	(0.011)	(0.016)
Covariates	-	√	-	√	-	√
Year FE	√	√	√	√	√	√
Country FE	√	√	√	√	√	√

Countries	30	30	28	28	16	16
Observations	180	180	168	168	96	96

Notes: Columns (1) to (4) estimates the equation (2) in Section 3.2. Control variables include employed labour force (% of total population), human capital index (scores=0 to 1), labour compensation (% of GDP), gross fixed capital formation (% of GDP) and government expenditure (% of GDP). Robust standard errors in parentheses are bootstrapped with 1,000 replications. ***, **, and * indicate statistical significance at 1%, 5% and 10% nominal level, respectively.

Digital inclusion has significant positive impact on labour productivity in Asia-Pacific countries. However, magnitude of these impacts are smaller. This is no surprise as Asia-Pacific region is having considerably higher digital inclusion scores before and after the pandemic. Direction of the impacts remain unchanged even when the digital inclusion is decomposed into its domains: availability, affordability, relevance and readiness. Considering the smaller magnitude of the impacts, policies that encourage complementary investments in process development should be encouraged (Mollins & Taskin, 2023).

Knowing to what extent digitalisation leads to productivity ensures achieving economic growth and prosperity. Digitalization influences labour productivity through various channels. Investment in digital goods and digital intermediate inputs are vital. Digitalization of business processes and percentage of people with higher education in the workforce significant for productivity (Varlamova & Larionova, 2020). Hence, governments implementing policies toward internetization, business digitalization and e-commerce are suggested.

4.2.3 Heterogeneous Digitalization Effects Across Income Levels

The heterogeneous impacts of digitalization by income levels as categorised by the World Bank income groups for developing countries are shown in Table 5. Except the high income and upper-middle income country categories, digital inclusion of the countries in lower-middle and low income categories show negative impact on labour productivity. High income group countries have more opportunities for enhanced digitalization (Tian & Xiang, 2024; Singh & Jyoti, 2023). So that, high income economies have better opportunities to enhance productivity than the low income economies.

Table 5: Estimates of Digital Inclusion on Labour Productivity, by Income

	(2)	**(2)**	**(2)**	**(2)**
	High Income	**Upper-Middle Income**	**Lower-Middle Income**	**Low Income**
Outcome variable: Output per hour worked				
Digital inclusion	0.020	0.002	-0.001	-0.001
	(0.011)	(0.005)	(0.003)	(0.004)
Availability	0.020*	0.002	-0.001	0.0001
	(0.010)	(0.006)	(0.004)	(0.007)
Affordability	0.016	0.001	-0.001	-0.001
	(0.009)	(0.004)	(0.002)	(0.003)
Relevance	0.027*	0.002	-0.0004	-0.002
	(0.012)	(0.005)	(0.003)	(0.004)

Readiness	0.019	0.003	0.000	-0.001
	(0.012)	(0.006)	(0.003)	(0.003)
Outcome variable: Growth rate of output per worker				
Digital inclusion	0.017*	0.008	-0.027	0.012
	(0.149)	(0.012)	(0.015)	(0.035)
Availability	0.016*	0.008	-0.032	0.010
	(0.007)	(0.013)	(0.018)	(0.056)
Affordability	0.012*	0.006	-0.020	0.004
	(0.006)	(0.010)	(0.012)	(0.024)
Relevance	0.029**	0.013	-0.023	0.021
	(0.009)	(0.013)	(0.015)	(0.029)
Readiness	0.017*	0.009	-0.033*	0.017
	(0.008)	(0.013)	(0.017)	(0.029)
Covariates	√	√	√	√
Year FE	√	√	√	√
Country FE	√	√	√	√
Countries	35	21	28	12
Observations	210	126	168	72

Notes: Columns (1) to (4) estimates the equation (2) in Section 3.2. Control variables include employed labour force (% of total population), human capital index (scores=0 to 1), labour compensation (% of GDP), gross fixed capital formation (% of GDP) and government expenditure (% of GDP). Robust standard errors in parentheses are bootstrapped with 1,000 replications. ***, **, and * indicate statistical significance at 1%, 5% and 10% nominal level, respectively.

4.3 Robustness Tests

The validity of the identification strategy for the impact of digitalization on labour productivity is determined by using several robustness tests. The estimations repeated using the GMM estimation method. This provides evidence to understand whether the findings are sensitive to the econometric technique. Except for minor changes in the magnitude and the significance, the direction of the estimates remains unchanged.

The next robustness check omits six countries with worst and best average labour productivity growth rates during 2017-2022 period for developing countries. Worst: Venezuela (-11.9%), Sudan (-4.5%) and Angola (-4.3). Best: Ireland (6.0%), China (5.6%) and Vietnam (5.5). While all countries are unique, these countries are omitted from the estimations to determine if their scale of labour productivity is driving results. Omitting these countries shifts the estimations slightly. The magnitudes change but the direction of results similar to the base specification. This indicates that the measure of the impact of digitalization is not depending just on these significant countries.

5. Conclusion and Policy Implications

Digital inclusion ensures higher labour productivity. Digitalization encourages productivity gains that leads to long-term growth. Despite the world-wide productivity slow down during post-pandemic period, digital inclusion has positive impact on productivity in Asia-Pacific

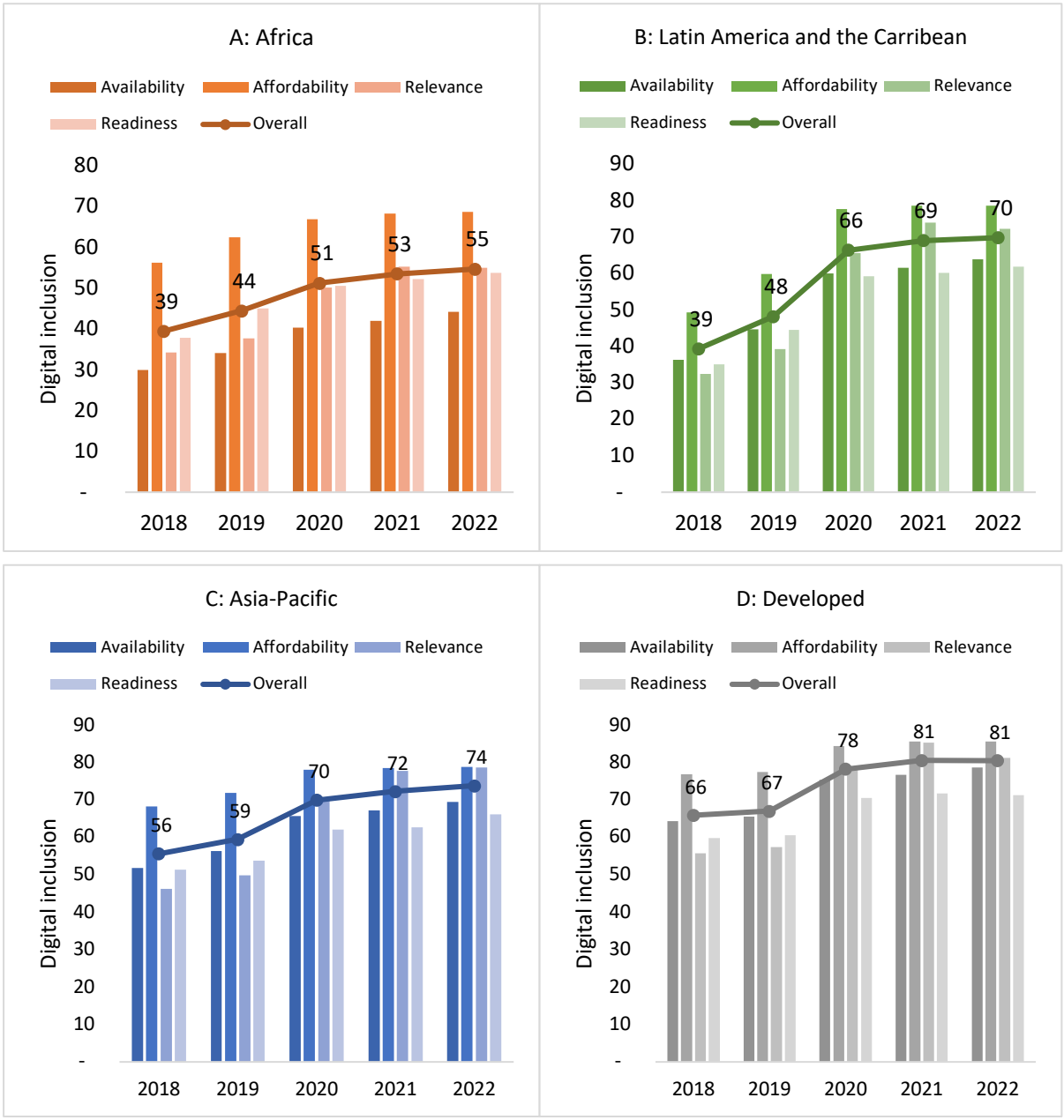
countries but not in the Africa and Latin America countries. These results are not surprising as the Asia-Pacific region owns the best digital inclusion scores amongst all developing countries. Removing the outliers (with highest and lowest productivity growths) deliver the same results.

Digitalisation affects labour productivity in various ways. Increased labour compensation and government spending are the most impactful drivers in improving labour productivity for developing countries. Considering the smaller impact sizes, it is proposed to encourage investments in complementary investments to harness the full benefits of digitalization.

Digitalisation drives structural growth and long-term economic growth through labour productivity enhancement. The level of digital adoption is heterogeneous across countries while advanced countries are ahead of developing economies. Investment in digital technologies is vital in improving labour productivity.

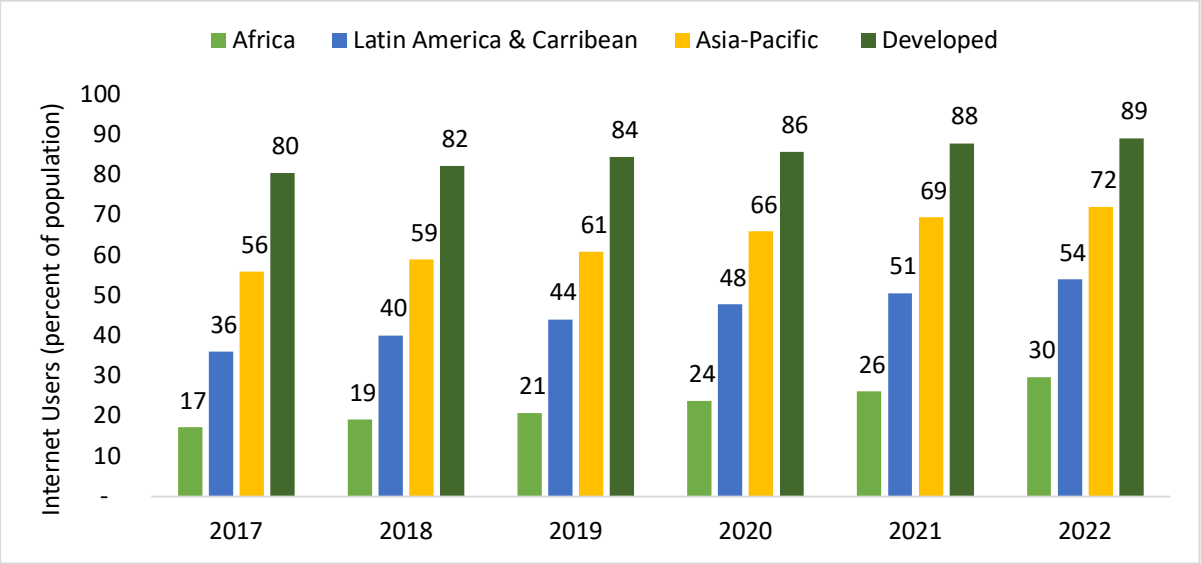
Appendix

Figure 1A: Digital Inclusion – Sub Domains



Source: Inclusive Internet Index 2024. Economist Impact. https://impact.economist.com/projects/inclusive-internet-index/.

Figure 2A: Internet Users



Source: Inclusive Internet Index 2024. Economist Impact.

Table 1A: Digitalization Country Classification

Developed Countries	Developing Countries		
	Africa	Asia and the Pacific	Latin America and the Caribbean
Australia	Algeria	Bahrain	Argentina
Austria	Angola	Bangladesh	Brazil
Belgium	Benin	Cambodia	Chile
Bulgaria	Botswana	China	Colombia
Canada	Burkina Faso	India	Cuba
Denmark	Cameroon	Indonesia	Dominican Republic
Estonia	Congo (DRC)	Iran	El Salvador
France	Côte d'Ivoire	Jordan	Guatemala
Germany	Egypt	Kuwait	Honduras
Greece	Ethiopia	Lebanon	Jamaica
Hungary	Gabon	Malaysia	Mexico
Ireland	Ghana	Mongolia	Panama
Italy	Kenya	Myanmar	Paraguay
Japan	Liberia	Oman	Peru
Lithuania	Madagascar	Pakistan	Trinidad & Tobago
Netherlands	Malawi	Philippines	Venezuela
New Zealand	Mali	Qatar	
Poland	Morocco	Saudi Arabia	
Portugal	Mozambique	Singapore	
Romania	Namibia	South Korea	
Spain	Nigeria	Sri Lanka	
Sweden	Rwanda	Thailand	
Switzerland	Senegal	Turkey	
United Kingdom	South Africa	UAE	
United States	Sudan	Vietnam	
	Tanzania		
	Tunisia		
	Uganda		
	Zambia		
	Zimbabwe		

Source: World Economic Situation Prospects (2024).

Table 2A: Inclusive Internet Index Domains

Availability (40%)	Affordability (30%)	Relevance (20%)	Readiness (10%)
Usage (25%)	Price (66.7%)	Local content (50%)	Literacy (33.3%)
Quality (25%)	Competitive environment (33.3%)	Relevant content (50%)	Trust and safety (33.3%)
Infrastructure (25%)			Policy (33.3%)
Electricity (25%)			

Source: Inclusive Internet Index 2024. Economist Impact.

Table 3A: Definitions of Variables

Variables	Definition	Source
Labour productivity (lp)	Output per hour worked, GDP constant 2017 international USD at PPP.	WDI
Labour productivity growth (glp)	Annual growth rate of output per worker. Total output produced per unit of labour, GDP constant 2017 international USD at PPP (%).	WDI
Digital inclusion ($digital$)	Inclusive internet index assessed internet inclusion across countries. Index scores ranged between 0 to 100, where 100=most inclusive internet environment.	EIU
Stringency index ($stringency$)	Intensity of government restrictions during the pandemic. Index scores ranged between 0 to 100, where 100=most stringent response.	OxCGRT
Labour force participation ($lfpr$)	Economically active population as a percentage of total population ages 15-64 (%).	WDI
Human capital index (hci)	Contributions of health and education to worker productivity. Index scores ranged from 0 to 1, where 1=child born today can expect to achieve full health and achieve formal education potential.	WDI
Labour compensation ($comp$)	Total compensation of employees, percent of GDP (%).	OWID
Gross fixed capital formation ($gfcf$)	Includes land improvements; plant, machinery, and equipment purchases; and construction of roads, railways, schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Given as percent of GDP (%).	WDI
Government expenditure ($gexp$)	Government spending, percent of GDP (%).	IMF

Notes: WDI=World Development Indicators of the World Bank; EIU=Economist Intelligence Unit; OxCGRT= Oxford Covid-19 government response tracker available in the Our World in Data web platform; OWID=Our World in Data web platform; IMF=International Monetary Fund.

Table 4A: Descriptive Statistics, Full- and Sub-Samples

Variables	Mean	Std. Dev.	Min	Max	Observations
Full Sample					
Outcome variable					
Labour productivity	26.805	24.057	1.32	141.64	576
Labour productivity growth	0.825	3.967	-20.477	21.333	576
Explanatory variables					
Digital inclusion	51.234	28.855	0.000	86.100	576
Stringency index	20.527	26.576	0.000	84.260	576
Labour force participation	68.149	10.439	40.726	89.623	576
Human capital index	0.560	0.168	0.000	0.887	576
Labour compensation	47.566	10.462	-2.680	70.600	576
Gross fixed capital formation	23.038	6.930	1.225	54.274	576
Government expenditure	30.460	12.205	7.340	69.200	576
Developed					
Outcome variable					
Labour productivity	57.357	20.034	23.390	141.640	150
Labour productivity growth	1.303	3.459	-10.235	15.509	150
Explanatory variables					
Digital inclusion	62.046	30.705	0.000	83.900	150
Stringency index	21.547	28.388	0.000	84.260	150
Labour force participation	75.679	5.071	64.424	84.153	150
Human capital index	0.750	0.053	0.584	0.844	150
Labour compensation	56.428	6.990	30.210	68.400	150
Gross fixed capital formation	22.411	4.810	10.687	54.274	150
Government expenditure	43.656	8.054	21.228	61.347	150
Developing					
Outcome variable					
Labour productivity	16.047	14.030	1.320	72.050	426
Labour productivity growth	0.656	4.122	-20.477	21.333	426
Explanatory variables					
Digital inclusion	47.435	27.207	0.000	86.100	426
Stringency index	20.168	25.933	0.000	84.260	426
Labour force participation	65.497	10.552	40.726	89.623	426
Human capital index	0.494	0.141	0.000	0.887	426
Labour compensation	44.445	9.669	-2.680	70.600	426
Gross fixed capital formation	23.258	7.529	1.225	43.849	426
Government expenditure	25.813	9.783	7.340	69.200	426
Africa					
Outcome variable					
Labour productivity	8.117	7.008	1.320	28.440	180
Labour productivity growth	0.537	3.888	-12.040	21.333	180
Explanatory variables					
Digital inclusion	40.523	22.360	0.000	74.300	180
Stringency index	17.197	22.462	0.000	74.070	180
Labour force participation	64.817	11.356	42.824	86.991	180
Human capital index	0.412	0.058	0.317	0.547	180

Labour compensation	43.967	8.301	27.000	70.600	180
Gross fixed capital formation	22.182	7.948	2.178	42.820	180
Government expenditure	23.593	8.092	7.340	42.428	180
Asia and the Pacific					
Outcome variable					
Labour productivity	26.499	18.273	3.290	72.050	168
Labour productivity growth	1.318	3.742	-12.093	8.709	168
Explanatory variables					
Digital inclusion	55.021	29.176	0.000	86.100	168
Stringency index	22.307	27.892	0.000	84.260	168
Labour force participation	66.990	12.274	40.276	89.623	168
Human capital index	0.617	0.116	0.389	0.887	168
Labour compensation	44.361	8.496	25.700	61.930	168
Gross fixed capital formation	26.118	6.725	1.225	43.849	168
Government expenditure	27.723	9.723	9.133	66.518	168
Latin America and the Caribbean					
Outcome variable					
Labour productivity	18.563	9.062	6.390	43.470	96
Labour productivity growth	-0.379	4.634	-20.477	7.551	96
Explanatory variables					
Digital inclusion	48.782	30.459	0.000	80.600	96
Stringency index	21.766	27.665	0.000	84.260	96
Labour force participation	66.883	4.897	54.763	80.781	96
Human capital index	0.487	0.192	0.000	0.674	96
Labour compensation	47.526	13.216	-2.680	67.930	96
Gross fixed capital formation	20.446	5.550	9.814	39.336	96
Government expenditure	29.262	12.239	9.312	69.200	96

Table 5A: Correlation Matrix

	lp	$digital$	$stringency$	$lfpr$	hci	$comp$	$gfcf$	$gexp$
lp	1.000							
$digital$	0.307	1.000						
$stringency$	0.057	0.451	1.000					
$lfpr$	0.168	0.091	-0.065	1.000				
hci	0.753	0.298	0.045	0.379	1.000			
$comp$	0.284	0.183	0.062	0.244	0.470	1.000		
$gfcf$	0.041	0.064	0.0001	0.139	0.178	-0.115	1.000	
$gexp$	0.602	0.232	0.124	0.258	0.450	0.420	-0.085	1.000

References

Abdelgany, M., & Saleh, A. (2022). Human capital and labor productivity: Empirical evidence from developing countries. *International Journal of Economics, Finance and Management Science, 10*(4), 173-184.

Acemoglu, D. (2003). Labor-and capital-augmenting technical change. *Journal of the European Economic Association, 1*(1), 1-37.

Acemoglu, D., & Restrepo, P. (2019). Automation and new tasks: How technology displaces and reinstates labor. *Journal of Economic Perspectives, 33*(2), 3-30.

Acemoglu, D., & Restrepo, P. (2022). Tasks, automation, and the rise in US wage inequality. *Econometrica, 90*(5), 1973-2016.

Acemoglu, D., Autor, D., Dorn, D., Hanson, G. H., & Price, B. (2014). Return of the Solow paradox? IT, productivity, and employment in US manufacturing. *American Economic Review, 104*(5), 394-399.

Adam, I. O., & Dzang, A. M. (2021). Bridging the global digital divide through digital inclusion: the role of ICT access and ICT use. *Transforming Government: People, Process and Policy, 15*(4), 580-596.

Ahmad, N., Ribarsky, J., & Reinsdorf, M. (2017). Can potential mismeasurement of the digital economy explain the post-crisis slowdown in GDP and productivity growth? *OECD Statistics Working Papers 2017/09*.

Albani, M., Anyfantaki, S., & Lazaretou, S. (2019). How do digital technologies drive Greece's economic growth? Opportunities and challenges. *Bank of Greece Economic Bulletin*(49).

Aleksandrova, A., Truntsevsky, Y., & Polutova, M. (2022). Digitalization and its impact on economic growth. *Brazilian Journal of Political Economy, 42*(2), 424-221.

Anghel, B. B. (2024). Digitalisation and Productivity. *ECB Occasional Paper, 2024/339*.

Anghel, B., B. S., Bijnens, G., Botelho, V., Falck, E., Labhard, V., . . . Strobel, J. (2024). Digitalisation and Productivity. *ECB Occasional Paper, 339*.

Autor, D. (2014). Polanyi's paradox and the shape of employment growth. *National Bureau of Economic Research.*, 20485.

Balsmeier, B., & Woerter, M. (2019). Is this time different? How digitalization influences job creation and destruction. *Research Policy, 48*(8), 103765.

Banday, T., & Erdem, E. (2024). ICT and declining labour productivity in OECD. *SN Business & Economics, 4*(3), 33.

Barro, R. J., & Lee, J. W. (1996). International measures of schooling years and schooling quality. *The American Economic Review, 86*(2), 218-223.

Bergeaud, A., Cette, G., & Lecat, R. (2016). Productivity trends in advanced countries between 1890 and 2012. *Review of Income and Wealth, 62*(3), 420-444.

Bergeaud, A., Malgouyres, C., Mazet-Sonilhac, C., & & Signorelli, S. (2021). Technological change and domestic outsourcing. *Discussion Papers-Discussion Papers*, 1784.

Bloom, N., Sadun, R., & Reenen, J. V. (2012). Americans do IT better: US multinationals and the productivity miracle. *American Economic Review, 102*(1), 167-201.

Borowiecki, M., Pareliussen, J., Glocker, D., Kim, E. J., Polder, M., & Rud, I. (2021). The impact of digitalisation on productivity: Firm-level evidence from the Netherlands. *OECD Economics Department Working Papers*, 1680.

Brussevich, M., Dabla-Norris, M. E., Kamunge, C., Karnane, P., Khalid, S., & Kochhar, M. K. (2018). Gender, technology, and the future of work. *International Monetary Fund - Discussion Notes, SDN/18/07*.

Brynjolfsson, E., Rock, D., & Syverson, C. (2019). Artificial intelligence and the modern productivity paradox. *The economics of artificial intelligence: An agenda, 23*, 23-57.

Calvino, F., & Criscuolo, C. (2019). *Business dynamics and digitalisation.* Paris: OECD Publishing.

Codagnone, C. (2022). *Vienna study on inclusive innovation for growth and cohesion: modelling and demonstrating the impact of e-inclusion.* Brussels: European Commission.

Dahl, C. M., Kongsted, H. C., & Sorensen, A. (2011). ICT and Productivity Growth in the 1990s: Panel Data Evidence on Europe. *Empirical Economics, 40*, 141-164.

Dauth, W., Findeisen, S., Suedekum, J., & Woessner, N. (2021). The adjustment of labor markets to robots. *Journal of the European Economic Association, 19*(6), 3104-3153.

Decker, R. A., Haltiwanger, J., Jarmin, R. S., & Miranda, J. (2017). Declining dynamism, allocative efficiency, and the productivity slowdown. *American Economic Review, 107*(5), 322-326.

Deschacht, N. (2021). The digital revolution and the labour economics of automation: A review. *ROBONOMICS: The Journal of the Automated Economy, 1*, 1-8.

Dua, P., & Garg, N. K. (2019). Determinants of labour productivity: Comparison between developing and developed countries of Asia-Pacific. *Pacific Economic Review, 24*(5), 686-704.

EI. (2024). *The Inclusive Internet Index*. Retrieved from Economist Impact: https://impact.economist.com/projects/inclusive-internet-index/

EIU. (2024). *The inclusive internet index*. Retrieved from The Economist Impact: https://impact.economist.com/projects/inclusive-internet-index/2022

Engelbrecht, H. J., & Xayavong, V. (2006). ICT intensity and New Zealand's productivity malaise: Is the glass half empty or half full?. *Information Economics and Policy, 18*(1), 24-42.

Fedotenkov, I., & Gupta, R. (2021). The effects of public expenditures on labour productivity in Europe. *Empirica, 48*(4), 845-874.

Fernald, J. G. (2015). Productivity and Potential Output before, during, and after the Great Recession. *NBER Macroeconomics Annual, 29*(1), 1-51.

Fuentes-Castro, D. (2012). Labour productivity and compensation of employees in Europe. *Applied Economics Letters, 19*(7), 689-693.

Gal, P., Nicoletti, G., Renault, T., Sorbe, S., & Timiliotis, C. (2019). Digitalisation and productivity: In search of the holy grail–Firm-level empirical evidence from EU countries. *OECD Economics Department Working Papers*, 1533.

Goldin, I., Koutroumpis, P., Lafond, F., & Winkler, J. (2024). Why is productivity slowing down? *Journal of Economic Literature, 62*(1), 196-268.

Gu, W., & Willox, M. (2018). Productivity Growth in Canada and the United States: Recent Industry Trends and Potential Explanations. *International Productivity Monitor, 35*, 73-94.

ILO. (2024). *ILOSTAT*. Retrieved from International Labour Organisation: https://ilostat.ilo.org/topics/labour-productivity/#:~:text=Labour%20productivity%20represents%20the%20total,a%20given%20time%20reference%20period.

IMF. (2024). *Government expenditure, percent of GDP* . Retrieved from International Monetary Fund:

https://www.imf.org/external/datamapper/exp@FPP/USA/FRA/JPN/GBR/SWE/ESP/ITA/ZAF/IND

Ivanov, S., Kuyumdzhiev, M., & Webster, C. (2020). Automation fears: Drivers and solutions. *Technology in Society, 63*, 101431.

Jahan, N., & Zhou, Y. (2023). COVID-19 and digital inclusion: Impact on employment. *Journal of Digital Economy, 2*, 190-203.

Jajri, I., & Ismail, R. (2010). Impact of labour quality on labour productivity and economic growth. *African Journal of Business Management, 4*(4), 486.

Jaumotte, F., Oikonomou, M., Pizzinelli, C., & Tavares, M. M. (2023). *How Pandemic Accelerated Digital Transformation in Advanced Economies.* Retrieved from IMF Blog: https://www.imf.org/en/Blogs/Articles/2023/03/21/how-pandemic-accelerated-digital-transformation-in-advanced-economies

Kapeliushnikov, R. I. (2015). Labor productivity and labor compensation: Some simple arithmetic. *Problems of Economic Transition, 57*(11), 1-34.

Karacuka, M., Myovella, G., & Haucap, J. (2024). roductivity paradox in Africa: Does digitalization foster labor productivity in African economies? *Journal of the Knowledge Economy*, 1-20.

Kindberg-Hanlon, G., & Okou, C. (2020). *Productivity Convergence: Is Anyone Catching Up?.* Washington: World Bank.

Malgouyres, C., Mayer, T., & Mazet-Sonilhac, C. (2021). Technology-induced trade shocks? Evidence from broadband expansion in France. *Journal of International Economics, 133*(103520).

Mankiw, N. G., Romer, D., & Weil, D. N. (1992). A contribution to the empirics of economic growth. *The Quarterly Journal of Economics, 107*(2), 407-437.

Markhaichuk, M., & Panshin, I. (2022). The impact of digital literacy on labor productivity in the context of the educational environment transformation. *Eurasian Journal of Educational Research, 97*(97), 86-102.

McMillan, M., Rodrik, D., & Verduzco-Gallo, Í. (2014). Globalization, structural change, and productivity growth, with an update on Africa. *World Development, 63*, 11-32.

Meloni, W. M., & Stirati, A. (2023). The decoupling between labour compensation and productivity in high-income countries: Why is the nexus broken? *British Journal of Industrial Relations, 61*(2), 425-463.

Mollins, J., & Taskin, T. (2023). Digitalization: Productivity. *Bank of Canada Staff Discussion Paper, 2023-17*, 1-46.

Nekarda, C. J., & Ramey, V. A. (2011). Industry evidence on the effects of government spending. *American Economic Journal: Macroeconomics, 3*(1), 36-59.

Nguyen, T. H. (2024). Does Digitalization Really Foster Economic Growth in the Context of the COVID-19 Pandemic?. *ADB Working Paper Series*, 1472.

OWID. (2024). *Total confirmed COVID-19 deaths and cases per million people,*. Retrieved from Our World in Data: https://ourworldindata.org/grapher/total-covid-cases-deaths-per-million

OxCGRT. (2024). *COVID-19: Stringency Index*. Retrieved from Our World in Data: https://ourworldindata.org/covid-stringency-index

Papanyan, S. (2015). Digitization and Productivity: Measuring Cycles of Technological Progress. *Working Papers 15/33. BBVA Bank, 15*(33).

Quiggin, J. (1999). Human capital theory and education policy in Australia. *Australian Economic Review, 32*(2), 130-144.

Samargandi, N. (2018). Determinants of labor productivity in MENA countries. *Emerging Markets Finance and Trade, 54*(5), 1063-1081.

Shakya, S., & Plemmons, A. (2022). Productivity spillovers and the productivity–compensation gap. *Spatial Economic Analysis, 17*(3), 354-369.

Singh, A. K., & Jyoti, B. (2023). Empirical evidence from different income group countries on the interdependency between digitalization and economic development. *Artificial Intelligence, and Next Generation Internet of Things: Digital Innovation for Green and Sustainable Economies*, 44-85.

Sinha, M., Roy, S., & Tirtosuharto, D. (2024). Digitalization and economic development: lessons from globalized developing countries. *Studies in Economics and Finance*.

Syverson, C. (2011). What determines productivity? *Journal of Economic Literature, 49*(2), 326-365.

Syverson, C. (2017). Challenges to Mismeasurement Explanations for the US Productivity Slowdown. *The Journal of Economic Perspectives, 31*(2), 165-186.

Tang, J., & Wang, W. (2004). Sources of aggregate labour productivity growth in Canada and the United States. *Canadian Journal of Economics, 37*(2), 421-444.

Tian, L., & Xiang, Y. (2024). Does the digital economy promote or inhibit income inequality? *Heliyon, 10*(14).

UNSDG. (2024). *UN SDG Indicator Metadata.* United Nations.

Van Ark, B. (2016). The productivity paradox of the new digital economy. *International Productivity Monitor, 31*, 3-18.

Varlamova, J., & Larionova, N. (2020). Labor Productivity in the Digital Era: A Spatial-Temporal Analysis. *International Journal of Technology, 11*(6).

WDI. (2024). *World Development Indicators*. Retrieved from World Bank: https://data.worldbank.org/indicator/NE.GDI.FTOT.ZS

WGI. (2024). *Worldwide Governance Indicators*. Retrieved from World Bank: https://www.worldbank.org/en/publication/worldwide-governance-indicators

Wolff, E. (1991). Capital formation and productivity convergence over the long term. *American Economic Review*, 565-579.