

From digital inequality to income inequality: exploring the multifaceted impact of digital literacy on income

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Abstract

Purpose – This study aims to examine the impact of digital literacy as a major component of digital inequality on the total income of individuals (a major component of economic inequality) in Sri Lanka, emphasizing the variations observed due to several demographic and geographical factors.

Design/methodology/approach – A baseline regression analysis using ordinary least squares was conducted, followed by an instrumental variable approach to address potential endogeneity. Variables such as age, education, gender, sector and employment status were included alongside digital literacy to examine their combined effect on total income. A logit model assessed digital literacy's impact across income levels, while heterogeneity analysis explored how digital literacy influenced total income in diverse groups with distinct attributes.

Findings – This study reveals that digital literacy significantly increases total income for individuals in Sri Lanka, as affirmed by various analyses used in the study. Results further indicate that demographic characteristics, such as age, gender, level of education, location, employment status and digital literacy, significantly affect individuals' total income.

Originality/value – This study contributes to the literature in multiple ways by exploring the impact of digital literacy on income inequalities by concentrating on different strata of society without focusing on one segment of society, focusing on individuals in a developing country in South Asia to investigate the income inequalities based on their level of digital literacy and using Labour Force Survey data to conduct research on digital inclusion and digital inequality.

Keywords Digital literacy, Digital inequality, Total income, Economic inequality, SDGs, Sri Lanka

Paper type Research paper

(Information about the authors can be found at the end of this article.)

JEL classification – C12, C13, C36, D31, I24, Q01

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1. Introduction

The fourth industrial revolution (rapid technological advancements in the 21st century) and the information age have created various digital inequalities among different segments of society (Frederick, 2019). Those who possess digital infrastructure and digital skills are now well understood to enjoy the advantages of a digital society over those who have less access to digital infrastructure or lack digital skills. These digital inequalities ultimately contribute to increasing social inequalities. With the proliferation of the internet, digital inequality is becoming more prominent among several other forms of disparities in society (Ragnedda Massimo, 2013). Moreover, this leads to a myriad of problems in society because digital inequality is combined with several other forms of socioeconomic and cultural determinants, such as gender, race, ethnicity and income (Kerras et al., 2020; Ragnedda and Muschert, 2013). With the inception of advanced computing, communication devices and related digital technologies, including the internet, the requirement for digital competency has become extremely important. Accordingly, concerns about digital skills and the lack of digital

competencies (second-level digital divide) have become more focused on digital divide/digital inequality research (van Dijk, 2020).

Examining the impact of digital literacy on income is crucial for several reasons. Firstly, due to the fourth industrial revolution, digital technologies have become essential for engaging in every sector in the present world, such as business, education and health. Therefore, new business and employment opportunities and unique sectors such as online gig work have emerged, potentially leading to new income-generating sources or higher income levels. Apart from that, various destructive technologies in the present digital world increase the efficiency and effectiveness of existing systems and processes, ultimately leading to an enhanced income; therefore, it is imperative to examine the impact of digital literacy on individuals' income levels.

To examine the impact of digital literacy on total income, the 2020 Sri Lankan Labour Force Survey (LFS) data was used. Several reasons motivated the choice of Sri Lanka for the empirical analysis. Firstly, Sri Lanka, one of the developing nations with a high literacy rate, is afflicted by unfavourable economic conditions that prevent the development of adequate digital infrastructure and resources. Several governments have introduced various programs to enhance their citizens' digital literacy level to enhance their income and social standards; however, the success of those programs is still questionable. Secondly, Sri Lanka has been facing the worst economic crisis since its independence. Even though this study uses 2020 LFS data, the results of exploring the impact of digital literacy on the income level of individuals would be a critical finding for policymakers when implementing future projects while also addressing the root causes of the economic crisis.

Accordingly, the objective of this study is two-fold: to examine the impact of digital literacy on the total income of individuals in Sri Lanka, with particular emphasis on the variations observed across several demographic factors and different sectors within the country, and to explore the existing position of Sri Lankan computer literacy and digital literacy based on the households' and individuals' demographic and social characteristics. In doing so, this study contributes to the literature in multiple ways: existing studies on the impact of digital literacy on income inequalities mainly focus on one segment of society, such as rural communities. The present study considers exploring the impact of digital literacy on income inequalities by concentrating on multiple strata of society to obtain a comprehensive and nuanced understanding; digital divide/inequality in South Asian countries remains significantly higher due to infrastructural and affordability issues, language barriers and other socioeconomic and cultural issues (Zhou *et al.*, 2011; Kamanga, 2024); however, a lack of research has been conducted in the South Asian region employing comprehensive methodologies that account for the multifaced nature of digital literacy on the income level of the people in the region. This study addresses that research gap. The present study uses the LFS data to research digital inclusion and digital inequality considering several aspects of individuals and uses advancing methodologies, such as the Instrumental Variable (IV) model, Logit model, interaction terms and heterogeneity analysis, to obtain a more comprehensive understanding of the relationship.

The remainder of this article is organized as follows: Section 2 presents a review of relevant literature, identifying key theories of digital literacy and the gaps in existing literature. Section 3 outlines the research design, including objectives, research questions, data and empirical model. Section 4, the results and analysis, discusses the findings of different models used in the present study. Section 5 provides a comprehensive discussion highlighting the theoretical implications and implications for policymakers. Finally, Section 6 concludes the study by summarizing limitations and future research directions.

2. Review of the relevant literature research questions

This brief literature review explores the concept of digital literacy, specifically focusing on theoretical developments, including definitions, the role of digital literacy in the present

digital economy and its impact on individuals' incomes. Accordingly, this section identifies the research gap and develops the research questions using the review.

2.1 Theoretical developments and the role of digital literacy

One of the earliest definitions of digital literacy was published by [Gilster \(1997\)](#) as an essential literacy tool for the digital age. The term digital literacy can be defined as “those capabilities which fit an individual for living, learning and working in a digital society” ([NHS England, 2017](#)). Similarly, the [Department of Education Skills and Employment Australia \(2020\)](#) defined digital literacy as “the skills and competencies needed to use digital technologies to achieve personal goals, enhance employability skills and support education and training.” (p. 4) Therefore, digital literacy goes beyond simple ICT skills and knowledge and requires a more advanced set of competencies to work in a digital society ([Stephen, 2010](#)). The theories in digital divide research focus on the use of technology, such as the Uses and Gratification Theory and Social Cognitive Theory ([van Dijk, 2020](#)). The Uses and Gratification Theory is based on users' motivation to gain and create skills to select specific media and obtain gratifications by using it ([Oberiri and Omar, 2021](#)). At the same time, Social Cognitive Theory is based on learning the users' media usage through observation; in other words, it is the social learning of the people ([Bandura, 2001](#)). Moreover, there are theories that fall under the materialist perspective, where the main concerns are “economic means and social opportunities” to obtain digital media ([van Dijk, 2020](#)). The most popular theory under this perspective is Capital Theory, which consists of three main components: economic capital, social capital and cultural capital ([Bourdieu, 1986](#)). According to Capital Theory, access to digital technology is based on factors such as social networks and connections, learning a language, obtaining knowledge, devices, software subscriptions and hardware.

According to the Digital Literacy Development Model introduced by [Sharpe and Beetham \(2010\)](#), there are four stages of developing digital literacy (digital literacy development pyramid): access and awareness, in which opportunities to explore digital technologies are presented (“I have”); skills, which offer opportunities to improve digital competencies (“I can”); practices, which give opportunities to use digital skills in the real world (“I do”); and identity, which involves attitudes to use and improve digital literacies (“I am”). This study primarily considers the Digital Literacy Development Model as its theoretical lens since this model effectively elucidates the potential for income generation across the four stages of digital literacy development.

2.2 Impact of digital literacy on income

Certain groups in the community are well known to be disadvantaged due to a lack of digital resources and digital skills, which prevents them from gaining access to improved economic and social opportunities, leading to various types of inequalities ([Ragnedda and Muschert, 2013](#); [Liu et al., 2017](#)). For example, the literature has emphasized that the digital literacy gaps between male and female, urban and rural communities and different age groups may also significantly impact the level of digital participation and, ultimately, the economic and social standards ([Wang et al., 2022](#); [Zhong et al., 2022](#)). The literature shows the role of urban-rural income gaps, especially in high-income individuals, when it comes to exploring the contribution of digital literacy to them and the role of rural individuals' internet skills in enhancing their income in the digital realm ([O'Hara and Low, 2020](#)).

Digital literacy may be regarded as a contributing factor within the digital economy that can potentially exacerbate income inequalities associated with age ([Kim et al., 2023](#)). Some researchers have argued that the levels of digital literacy also depend on context and situation ([van Laar et al., 2020](#); [JISC, 2014](#)). For example, digital literacy development is influenced by the motivation levels of individuals to learn and enhance their digital skills in

different circumstances, such as career development, employment status and examinations (JISC, 2014). Therefore, the four stages of the Digital Literacy Development Model discussed above are closely related to an individual's income potential.

A significant portion of the existing literature on digital literacy and its impact on the income status of individuals and households has particularly focused on the subjective happiness of a person through individual welfare and economic welfare (Oswald and Wu, 2010; Wang *et al.*, 2022); however, little is known regarding the impact of digital literacy on the income levels of individuals. Only a limited body of literature on the impact of digital literacy on income inequalities among individuals in different social groups is available (Yao *et al.*, 2022; Bauer, 2018; Chen *et al.*, 2024). However, these studies have exclusively focused on digital connectivity as a whole or one segment of society, such as rural communities. Therefore, the present study intends to explore further the impact of digital literacy on income, considering individuals' socioeconomic and demographic characteristics.

3. Research design

3.1 Research questions

The following six research questions were developed based on the gaps identified from the review:

- RQ1. What are the existing computer and digital literacy levels (device usage and digital skills) in Sri Lanka, and how are they distributed among individuals based on demographic and social characteristics?
- RQ2. Does digital literacy significantly impact an individual's total income?
- RQ3. Do personal characteristics such as age, gender and number of years of education interact with digital literacy to have a combined effect on the total income?
- RQ4. Does the impact of digital literacy on the total income of individuals in Sri Lanka varies based on the geographical location (urban, rural or estate sectors)?
- RQ5. Does the impact of digital literacy on the total income of individuals in Sri Lanka varies based on the different levels of education (high and low)?
- RQ6. Does employment status interact with digital literacy to have a combined effect on the total income?

3.2 Data

To explore the research questions, this study uses the survey data from the 2020 LFS conducted by the Department of Census and Statistics (DCS) of Sri Lanka, which used two-stage stratified sampling processes. The Neyman allocation method was used to allocate primary sampling units to each district and sector (DCS, 2020). One section of the LFS questionnaire consists of digital literacy-related questions, which surveyed a sample of 65,535 Sri Lankan individuals. The data were collected at both the individual and household levels, as well as their economic and social characteristics. The age distribution of the sample was from 5 years to over 65 years (however, the present study considered only individuals over 10 years of age because the completion age of primary education in the Sri Lankan education system is 10 years). The main questionnaire consisted of 73 questions, and of those, 64 were on labour force participation, and the remaining were on the demographic profiles of the respondents. The digital literacy section of the LFS consisted of nine main questions that covered both computer and digital literacy: *Do you have the following digital devices (communication devices)? If yes, then how many? Are you aware of the activities done by the computer? Can you do some activity using a computer? What purposes? How did you get computer knowledge? Can you do some activity using a smartphone/Tablet? Did you use email at least once during the past 12 months? Did you*

use the internet at least once during the last 12 months? Which device did you use to connect to the internet/email? Where did you use the internet during the past 12 months?

One of the major concerns raised during the study is the definition of digital literacy used by the DCS for the survey. This definition considered only the ability to use computers, laptops, tablets and smartphones; however, the definition of digital literacy in the present digitalized context goes beyond the mere use of computing devices: It is a combination of several other dimensions, such as online digital participation skills. Therefore, this study considered the ability to use the internet as a proxy for online digital participation and included it as a component of digital literacy.

The individual's geographical location in Sri Lanka was classified into three levels: urban, rural and estate in the LFS. The estate sector classification was mainly based on the unique characteristics of plantation-based communities, which generally include geographical areas dedicated to tea, rubber and coconut plantations in Sri Lanka. These plantations are often owned by plantation companies or the government rather than by local residents. The estate population in Sri Lanka have unique socioeconomic and infrastructural conditions compared to urban and rural sector residents. Therefore, it is vital to consider the level of digital literacy and its impact on the income of individuals based on their geographical locations to facilitate tailored interventions.

3.3 Descriptive statistics

Columns 1–6 of Table 1 present device usage and devices used to connect to the internet/email, and Column 10 presents internet usage by Sri Lankan individuals. It is important to note that device usage and internet usage are calculated using individual-level data; however, a device used to connect to the internet/email is calculated using household-level data. As can be seen from Column 6, at the national level, the percentage of Sri Lankan individuals who use a computing device is steady at approximately 38%. Among them, more than 77% of individuals are using smartphones (out of total device usage, the percentage of smartphone usage). At the sector level, about 60% of urban individuals use a computing device. In comparison, this rate is 35% in the rural sector and only 17% in the estate sector ("Overall" was calculated by dividing the sector-wise device usage by the individual sector population). Nonetheless, smartphone usage among rural and estate sector individuals (78% and 91%, respectively) is higher than that of urban sector individuals, which is about 72%. Concerning gender, while 45% of male individuals reported using a computing device, only 31% of females reported using a computing

Table 1 Device and internet usage by individuals and households, Sri Lanka, 2020

Sector/gender (1)	Device usage (%)					Devices used to connect internet/email (%)			
	Desktop (2)	Laptop (3)	Tablet (4)	Smart phone (5)	Overall (6)	Desktop/laptop (7)	Smart phone (8)	Tablet (9)	Internet usage (%) (10)
Sri Lanka	6.1	15	2	77	37.8	21.8	76.9	1.5	32.7
Sector									
Urban	6	18.8	3.4	71.8	59.5	26.1	72.5	1.4	50.3
Rural	6.3	14	2.1	77.7	34.6	20.4	78	1.6	30.1
Estate	3.8	4.9	0	91.3	16.8	8.8	91	0.2	13.3
Gender									
Male	7.5	15.5	2.5	74.5	45.1	21.9	76.5	1.6	36.6
Female	4.4	14.4	2.2	79	31.3	21.7	76.9	1.4	29.1

Note(s): Device usage and internet usage are calculated using individual-level data. A device used to connect to the internet/email is calculated using household-level data. The Overall column shows the total number of devices used by Sri Lankan individuals (as a percentage) based on their sectors and genders

Source(s): Authors' own work

device (“Overall” was calculated by dividing the gender-wise device usage by the individual sector population); however, the percentage of smartphone usage among the female population (79%) is higher than their male counterparts (75%).

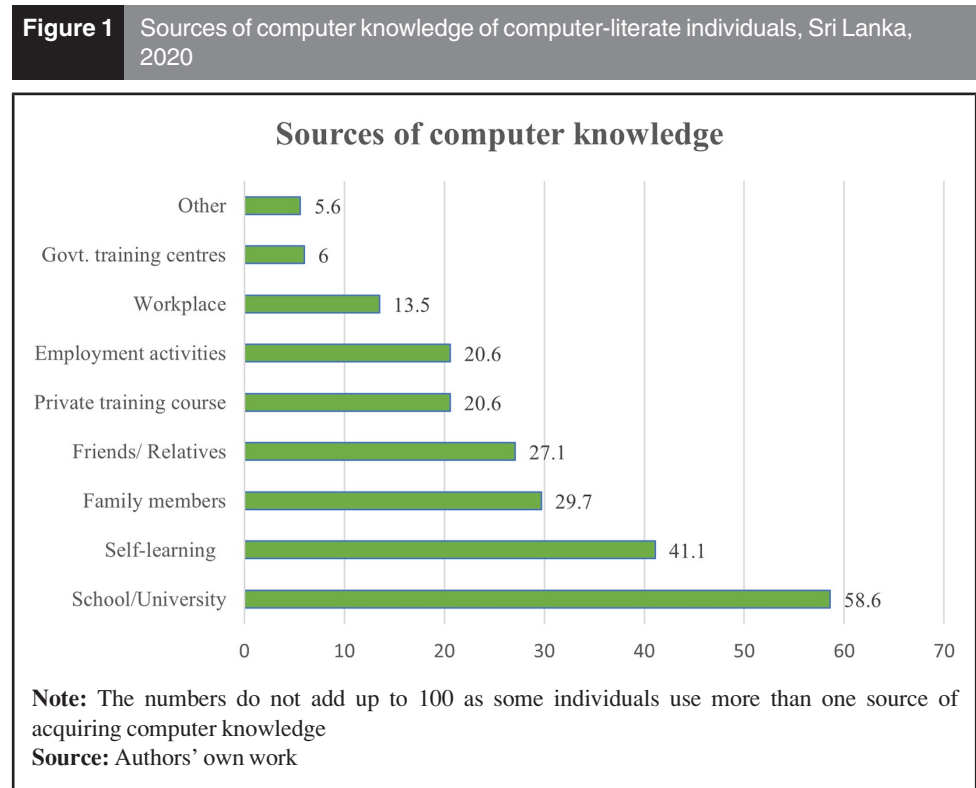
Columns 7–9 of [Table 1](#) present the percentage of Sri Lankan households by the type of device used to connect to the internet/email (out of total internet usage). At the national level, most households (77%) use smartphones to connect to the internet/email, followed by 22% using desktops/laptops. By gender, 77% of males and 77% of females use smartphones to connect to the internet/email. By sector, 73% of urban, 78% of rural and 91% of estate people use smartphones to connect to the internet/email. At all demographic levels, tablet computers are the least used to connect to the internet and email. The reason for smartphones being the most commonly used method could be due to affordability because smartphones are cheaper products to purchase than a desktop, laptop or tablet.

Column 10 of [Table 1](#) shows internet usage by individuals in 2020 by sector (urban, rural, estate) and gender. In 2020, the number of internet users in the urban sector was 50%, which is well over Sri Lanka’s average internet usage of 33% in the same year. However, other sectors – rural and estate – reported internet usage rates below the Sri Lankan average (30% and 13%, respectively). Moreover, in 2020, internet usage among the male population was 37%, compared with only 29% among females.

[Figure 1](#) presents the various sources of acquiring computer knowledge in Sri Lanka. The main source for individuals to acquire computer knowledge is school/university (58.6%), followed by self-learning (41.1%). The government training centres appeared to be the least accessed source by households for acquiring computer knowledge (6%).

3.4 Empirical model

The following empirical model [[equation \(1\)](#)] is constructed to examine the impact of digital literacy on the total income of individuals in Sri Lanka:



$$TI_i = \alpha + \beta Digital_i + \sum_j \gamma_j X_{ij} + \varepsilon_i \quad (1)$$

where α , β and the set of γ_j 's are parameters to be estimated; TI_i is the total monthly income of individual i from all the sources (the main and secondary occupations); $Digital_i$ is a dummy variable where $Digital_i = 1$ if the individual i is digitally literate and $Digital_i = 0$ if individual i is digitally illiterate (base category) and ε_i is the error term.

The DCS defined computer literate as, "A person (aged 5–69 years) is considered as a computer-literate person if he/she could use a computer on his/her own," (DCS, 2020, p. 1). Similarly, the DCS defined digital literate as "A person (aged 5–69) is considered as a digitally literate person if he/she could use a computer, laptop, tablet or smartphone on his/her own" (DCS, 2020, p. 1). Because internet skills are also regarded as one of the essential components of digital literacy, the ability to use the internet is also considered a component of digital literacy in the present study (van Deursen *et al.*, 2015). Consequently, digital literacy in this study is identified by combining three questions in the survey. The first two questions: "Can you do some activity using a computer?" and "Can you do some activity using a smartphone/tablet?" are both centered around proficiency in operating computing devices. The third question, "Did you use the internet at least once during the past 12 months?" is related to internet capabilities. If the answer is "yes" to all three questions for individual i , then a value of "1" is assigned to the digital literacy variable ($Digital_i$) and "0" otherwise. The variables X_i represent control variables (other factors or characteristics) that are expected to affect the total income of individual i . Seven control variables (X_i 's) have been used: age, gender, ethnicity, number of years of education, marital status, status of employment and residential sector in the model. Thus, the model used for the estimation purpose can be written as follows:

$$TI_i = \alpha + \beta Digital_i + \gamma_1 Age_i + \gamma_2 Age_i^2 + \gamma_3 Gender_i + \sum_{j=1}^5 \gamma_{4j} Ethnic_{ij} + \gamma_5 Education_i + \sum_{j=1}^4 \gamma_{6j} Marital_{ij} + \sum_{j=1}^3 \gamma_{7j} EmpStatus_{ij} + \sum_{j=1}^2 \gamma_{8j} Sector_{ij} + \varepsilon_i \quad (2)$$

Dummy variables are created for all categorical variables. $Digital_i$ is a dummy variable, as defined before, representing the digital literacy status of Sri Lankan individuals where $Digital_i = 1$ if the person is digitally literate and "0" if the person is digitally illiterate (base category). As age may have a non-linear relationship with income, both age and the squared term of age are included in the model. $Gender_i$ is a dummy variable where $Gender_i = 1$ if the individual is a male and "0" for a female (base category). $Ethnic_{ij}$ is a dummy variable representing the ethnicity of an individual i , taking value "1" if the individual belongs to ethnicity j ($j = 1$ [Tamil], 2 [Sri Lankan Moor], 3 [Malay], 4 [Burger], 5 [other]), and "0" otherwise, where Sinhala is the base category. $Marital_{ij}$ is a dummy variable for the current marital status of an individual i , which is equal to "1" if the individual i belongs to marital status j ($j = 1$ [married], 2 [widowed], 3 [divorced], 4 [separated]) and "0" otherwise, where "never married" is the base category. $EmpStatus_{ij}$ is a dummy variable for the status of employment of an individual i , which is equal to "1" if the individual belongs to employment status j ($j = 1$ [temporary], 2 [casual], 3 [no permanent employer] and "0" otherwise, where Permanent is the base category. DCS defines "no permanent employer" as the condition in which an individual does not have one permanent employer. Consequently, these employees are not entitled to annual paid leave or a formal appointment letter. $Sector_{ij}$ is a dummy variable to denote the residential location of an individual i , which is equal to "1" if the individual belongs to the sector j ($j = 1$ [rural], 2 [estate]) and "0" otherwise, where the urban sector is the base category. $Education_i$ represents the number of years of education of individual i .

Because child participants who do not earn any form of income have participated in the survey, this study considered only individuals over 10 years of age, as the completion age of primary education in the Sri Lankan education system is 10 years. A baseline regression analysis is performed using the ordinary least squares (OLS). The endogeneity problem can arise due to two main reasons in the present study: firstly, due to the omission of important variables that can have an impact on the digital literacy of an individual, and secondly, due to reverse causality; that is, while digital literacy may impact an individual's income, an individual's income level can also change their digital literacy level. Therefore, the model's potential endogeneity issues have been investigated in the present study. The model is re-estimated using the IV approach to address the endogeneity issue. Moreover, interaction terms are used to investigate the combined effect of selected predictor variables on total income. The variables age, years of education, gender, sector and status of employment are used in the present study with digital literacy to examine the combined effect on total income. The Logit model is used to investigate further the impact of digital literacy on different income levels of individuals based on the Sri Lankan official poverty line. Furthermore, heterogeneity analysis is performed to examine the influence of digital literacy on the total income of individuals belonging to various groups characterized by distinct attributes.

4. Results and analysis

4.1 Model estimation

4.1.1 Ordinary least squares regression. Equation (2) is estimated using the OLS method, and the results are reported in Columns 2 and 3 of Table 2. As can be seen, digital literacy has a positive and significant impact on total income. The estimated coefficient reveals that, when all other variables are held constant, a digitally literate person will earn about Rs. 14,558 more than a digitally illiterate person. The majority of the control variables are statistically significant at the 1% significant level except for a few variables (ethnic: Malay, ethnic: Burger, ethnic: Other, marital: divorced, marital: separated and marital: widowed).

The robustness testing of the estimation results is crucial to ensure that the model includes all important variables to mitigate possible bias due to endogeneity issues (Zhong *et al.*, 2022). In light of the study's primary objective, which is to examine the impact of digital literacy on an individual's total income, it is imperative to account for potential endogenous effects due to omitted variables that are correlated with the control variables or due to reverse causality between total income and digital literacy. The p -value of the Durbin and Wu-Hausman endogeneity test is 0.000, which is less than 0.05; therefore, the null hypothesis that "variables are exogenous" should be rejected. Thus, we conclude that the model has a potential endogeneity problem that can lead to estimation bias.

Several control variables related to the personal and social characteristics of individuals involved in the study are introduced to the model to mitigate the endogeneity issue. However, it is difficult to introduce all possible unobserved variables to the model. Therefore, the IV estimation method was used to re-estimate the model to overcome the endogeneity issue. Because awareness of computer activities may have a direct impact on digital literacy while only having an indirect impact on income via digital literacy and is not expected to be correlated with the error term, the variable "awareness of computer activities" has been employed as an IV for digital literacy to re-estimate the model. Even though a few other potential IVs, such as internet penetration rate and the number of computers used per 100 people, were found in the literature (Chen *et al.*, 2024), only one IV has been used due to data limitations. Columns 4 and 5 of Table 2 report the IV estimation results for equation (2). As can be seen, digital literacy has a significant positive impact on the total income of Sri Lankan individuals at a 1% level of significance. These results are consistent with the results of the OLS regression. The F value of the first-stage regression summary statistics is 969.86, greater than the 5% t critical value of 16.38, indicating that the

Table 2 Model estimation results, Sri Lankan individuals, 2020

Independent variables (Respondent characteristics) (1)	OLS		IV		Logit model		Marginal effect (8)
	Coefficient (2)	SE (3)	Coefficient (4)	SE (5)	Coefficient (6)	Odds ratios (7)	
<i>Digital literacy</i>							
Digitally illiterate (reference)							
Digital	14,557.6***	497.1	25,398.5***	2,108.1	1.357***	3.85***	
<i>Age</i>							
Age	881.8***	103.0	1025.3***	107.9	0.02***		0.0005***
Age ²	7.9***	1.2	8.8***	1.2	–		
<i>Gender</i>							
Female (reference)							
Male	5,960.8***	416.8	6,248.2***	426.1	0.144***	0.87***	
<i>Ethnicity</i>							
Sinhala (reference)							
Tamil	3,371.2***	510.8	2,408.7***	549.0	0.594***	0.55***	
Moor	4,261.5***	768.6	3,887.0***	782.6	0.514***	0.59***	
Malay	525.3	6,790.2	555.9	6,889.2	2.433	11.39	
Burger	1,453.0	6,080.7	3,515.6	6,178.9	0.784	2.19	
Other	13,064.1	9,600.1	17,450.5**	9,770.9	0.305	0.73	
<i>No. of years of education</i>							
Education	1,437.6***	67.8	970.4***	111.8	0.123***		0.013***
<i>Marital status</i>							
Never married (reference)							
Married	1,551.6***	586.6	2,182.4***	606.7	0.157***	0.85**	
Divorced	567.4	2,671.4	2,234.0	2,727.4	0.200	1.22	
Separated	346.8	1,519.9	2,187.8	1,580.1	0.318***	0.727**	
Widowed	658.2	1,246.5	1,870.5	1,284.7	0.464***	0.63***	
<i>Status of employment</i>							
Permanent (reference)							
Temporary	21,824.5***	492.7	19,203.0***	703.3	2.884***	0.055***	
Casual	21,442.4***	702.5	18,982.5***	850.5	2.752***	0.064***	
No permanent	28422.7***	619.2	25336.1***	856.8	4.991***	0.006***	
<i>Residential sector</i>							
Urban (Reference)							
Rural	5701.7***	512.3	4378.6***	576.5	0.531***	0.59***	
Estate	11298.7***	934.9	8889.4***	1051.6	1.557***	0.21***	
Constant	2439.7	2260.1	8959.3	2601.7	1.552		
R-squared	0.41		0.40				
F-test	590.91						
Chi-square			10227.87				

Note(s): The Age² variable has not been incorporated in the logit model, as an inverted U shape is not possible with the logit model. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Source(s): Authors' own work

null hypothesis “instruments are weak” can be rejected, and it can be concluded that the selected IV in the present study is acceptable.

The IV estimated coefficients in column 4 of Table 2 reveal that, when all other variables are held constant, a digitally literate person will earn Rs. 25,398.5 more than a digitally illiterate person (per month). A significant negative age-squared coefficient means the existence of a non-linear effect of age on income (inverted U-shaped relationship). The estimated coefficient of Age² reveals that the total income of an individual increases until the age reaches 58 years [(age coefficient/2 × (Age² coefficient)) = ← (1025.3/(2 × -8.8) = 58] and then decreases. Results further show that when all other variables are held constant, males earn Rs. 6248 more than females, a married person earns Rs. 2182 more than a never-married person, and Tamil

and Moor people earn Rs. 2408 and Rs. 3887 less than Sinhala people, respectively. Furthermore, on average, a 1-year increase in the number of years of education of an individual leads to an increase of Rs. 970 in their income. Similarly, another important variable that can impact digital literacy and total income is an individual's employment status. According to the results, when all other variables are held constant, temporary, casual and non-permanent employers (no permanent employers in the LFS are the employees without a permanent employer because they engage in precarious employment) earn Rs. 19,203, Rs. 18,982 and Rs. 25,336 less income per month, respectively, than a permanent employee.

4.1.2 Logit model. To further investigate the impact of digital literacy on the different income levels of individuals (by below-poverty and above-poverty income groups), the logit model is employed because the dependent variable has become a categorical variable. The official poverty line cut-off value of Rs. 13,777 set by DCS of Sri Lanka is used to stratify people into low-income and high-income groups. If the total income of an individual in the sample is below the poverty level of Rs 13,777, that individual is classified into the low-income group; if not, the individual is classified into the high-income group.

Columns 6–8 of [Table 2](#) present the Logit model results in the form of odds ratios and marginal effects. As can be seen, the odds ratio of the digital variable is 3.89, meaning that a digitally literate individual has a 289% [(odds ratio-1) × 100] higher likelihood of being in the high-income group than a digitally illiterate individual (the reference group). With regards to the residential sectors of persons, it is found that individuals residing in rural areas are 41% less likely (odds ratio = 0.59) to belong to the high-income category, while those in estate sectors are 79% less likely (odds ratio = 0.21) to belong to the high-income category compared to individuals residing in the urban sector (reference group).

Similarly, men are 13% less likely (odds ratio = 0.87) to belong to the high-income group than women (reference group); individuals belonging to ethnic groups, in particular the Tamils and Moors, are (45% and 40%, respectively) less likely (odds ratios 0.55 and 0.6, respectively) to belong to the high-income group than Sinhala (reference group), and married persons are 20% less likely (odds ratio = 0.8), separated persons are 32% less likely (odds ratio = 0.68) and widowed persons are 40% less likely (odds ratio = 0.6) to belong to the high-income group compared with a never-married person (reference group). In addition, an individual in the temporary, casual and non-permanent employment statuses has a lower likelihood (lower by 94%, 94% and 99%, respectively) of being categorized into the high-income group than an individual holding a permanent job (reference group).

Additionally, the findings suggest that a one-year increase in age is associated with a marginal effect of 0.0005 (Column 8 of [Table 2](#)), indicating a 0.05% higher likelihood of belonging to the high-income group at a 10% level of statistical significance. This likelihood of belonging to the high-income group is 1.3% higher for each one-year increase in the number of years of education, at a 1% level of significance.

4.1.3 Combined effect analysis. To find out the combined impact of digital literacy and several other variables on the total income of individuals, a combined effect (interaction) analysis was performed. Five variables, namely age, years of education, gender, sector and status of employment, were considered to conduct the combined effect analysis with the digital literacy variable. [Equation \(3\)](#) is the extended regression model of [equation \(2\)](#) after introducing the interaction terms. The interaction term “digital literacy*age” is introduced to [equation \(2\)](#) as the influence of age on digital literacy can be diverse, as those who have grown up with digital technology, known as digital natives, tend to engage with it to a greater extent than older adults, known as digital migrants ([Correa, 2015](#)). Nevertheless, the potential for young individuals to generate income through digital literacy may vary.

As per the literature, a person's education level is highly correlated with total income ([Scott and Jessica, 2017](#); [Yang et al., 2022](#)). Because education plays a key role in fostering digital literacy in today's world, digital literacy and the level of education can have a

combined effect on the total income of an individual, and the impact could be different at different educational levels. Therefore, the interaction term “digital literacy*number of years of education” is introduced to the model. In a country such as Sri Lanka, the gender of a person, together with digital literacy, can have a significant impact on the total income of a person due to several gender-based digital disparities. Therefore, to examine the combined effects of gender and digital literacy on total income, the interaction term “digital literacy*gender” is introduced to the model.

The digital literacy of individuals based on their residential sector in Sri Lanka can vary due to several factors, such as variations in infrastructure distribution among different sectors (Gamage and Halpin, 2007); therefore, an individual’s residential sector and digital literacy may impact combinedly on total income. To address this impact, the interaction term “digital literacy*sector” is introduced to the model. Similarly, digital literacy and employment status may combinedly impact an individual’s total income. The interaction term “digital literacy*status of employment” is introduced to the model based on an individual’s current employment status to address this impact:

$$\begin{aligned}
 Tl_i = & \alpha + \beta Digital_i + \gamma_1 Age_i + \gamma_2 Age_i^2 + \gamma_3 Gender_i + \gamma_4 Gender_i + \sum_{j=1}^5 \gamma_{4j} Ethnic_{ij} \\
 & + \gamma_5 Education_i + \sum_{j=1}^4 \gamma_{6j} Marital_{ij} + \sum_{j=1}^3 \gamma_{7j} EmpStatus_{ij} + \sum_{j=1}^2 \gamma_{8j} Sector_{ij} \\
 & + \gamma_9 (Digital_i * Age_i) + \gamma_{10} (Digital_i * Education) + \gamma_{11} (Digital_i * Gender_i) \\
 & + \sum_{j=1}^2 \gamma_{12,ij} Digital_i * Sector_{ij} + \sum_{j=1}^3 \gamma_{13,ij} (Digital_i * Empstatus) + \varepsilon_i \quad (3)
 \end{aligned}$$

Equation (3) is estimated using the IV method, and the results are reported in Table 3. As can be seen, digital literacy positively and significantly impacts the total income of Sri Lankan individuals. Similarly, all the selected variables, namely, age, years of education, gender, sector and status of employment interaction with digital literacy on total income, are statistically significant.

The results from the interaction model can be used for various policy-related issues. In Table 4, the income differences of two individuals were calculated based on some selected scenarios. This analysis of multiple scenarios was based on predicted incomes for those with a certain combination of characteristics. For example, in Scenario 1, the income difference between a digitally literate and a digitally illiterate 30-year-old two urban male residents with 11 years of formal education and who are employed full-time is Rs. 71,191.

Table 3 Estimated results of the model with interaction terms

	Coefficient	SE
<i>Digital literacy</i>		
Digital (β)	671228***	103090
<i>Interaction terms</i>		
Digital*Age (γ_9)	1283**	249
Digital*Education (γ_{10})	18513***	3177
Digital*Gender (γ_{11})	20305**	5312
Digital*Urban ($\gamma_{12,1}$)	337599***	51592
Digital*Rural ($\gamma_{12,2}$)	348173***	52467
Digital*Temporary ($\gamma_{13,1}$)	46862***	14570
Digital*Casual ($\gamma_{13,2}$)	45411***	14709
Digital*No_perm ($\gamma_{13,3}$)	68002***	19289
Control variables	Yes	Yes

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Source(s): Authors' own work

Table 4 Combined effect analysis using different scenarios

Scenario no.	Scenario	Income difference (combined effect) ($Y_{Digital} - Y_{Non-Digital}$)
1	Income difference between digitally literate and digitally illiterate 30-year-old urban males, both with 11 years of formal education and who are employed full-time	$\beta + \gamma_9 (\text{Age}) + \gamma_{10} (\text{Education}) + \gamma_{11} + \gamma_{12,1}$ $= 671,228 + (1,283 \times 30) + (18,513 \times 11) - 20,305 - 337,599$ $= 71,191$
2	Income difference between a 30-year-old digitally literate male living in the urban sector and a 30-year-old digitally illiterate male living in the rural sector, both with 11 years of formal education who are employed full-time	$\beta + \gamma_{8,1} - \gamma_{8,2} + \gamma_9 (\text{Age}) + \gamma_{10} (\text{Education}) + \gamma_{11} + \gamma_{12,1}$ $= 671,228 + 26,355 - 25,023 + (1,283 \times 30) + (18,513 \times 11) - 20,305 - 337,599$ $= 72,523$
3	Income difference between a digitally literate 30-year-old male who is employed full-time and a digitally illiterate 30-year-old male who is employed temporarily, both living in the urban sector with 11 years of formal education	$\beta - \gamma_{7,1} + \gamma_9 (\text{Age}) + \gamma_{10} (\text{Education}) + \gamma_{11} + \gamma_{12,1}$ $= 671,228 - 12,099 + (1,283 \times 30) + (18,513 \times 11) - 20,305 - 337,599$ $= 59,092$

Source(s): Authors' own work

Similarly, at the age of 50 years, this income difference is Rs. 45,531, and at the age of 70, this income difference is Rs. 19,871, respectively, showing the decreasing income difference with the age increase. Furthermore, when an individual's age increases by 1 year, the rate of change in income with respect to age between a digitally literate individual and a non-digitally literate individual is Rs. 1,283 ($= \gamma_9$). Scenario 2 investigates the income difference between a 30-year-old digitally literate male resident living in an urban sector and a 30-year-old digitally illiterate male resident living in a rural sector, both with 11 years of formal education and employed full-time. The corresponding total income difference is Rs. 72,523. Scenario 3 explores the income difference between a 30-year-old male digitally literate resident who is employed full-time and a digitally illiterate 30-year-old male resident who is employed temporarily, both of whom live in the urban sector with 11 years of formal education. According to the results, the combined impact on total income is Rs. 59,092. Moreover, when the number of years of education of a digitally literate person increases by 1 year, the total change in income is Rs. 15,391 ($= \gamma_5 + \gamma_{10}$). This change in income is Rs. 3,122 ($= \gamma_5$) for a digitally illiterate person.

4.1.4 Heterogeneity analysis – sub-group regression. Heterogeneity analysis is conducted to investigate the impact of digital literacy on the total income of individuals in different groups with distinct characteristics. Accordingly, individuals' geographical location (sector) was selected as a factor for conducting the sub-sample analysis since sectoral disparities are considered a significant policy concern. Similarly, education level (number of years of education) was selected to conduct the second sub-sample analysis to investigate the income variations towards groups with different educational levels. The results of the sub-group regression analysis for sectors (urban, rural, estate) and level of education are presented in Table 5. Accordingly, the sample was split into three groups based on the

Table 5 Group regression analysis results

Variables (1)	Urban (2)	Rural (3)	Estate (4)	Low education (5)	High education (6)
Digital	20887***	26393***	12801	20164***	27350***
p-value	0	0	0.219	0	0
Control variables	Yes	Yes	Yes	Yes	Yes
R-squared	0.323	0.41	0.246	0.335	0.249

Note(s): *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Source(s): Authors' own work

sectors, and the regression analysis (with IV estimation) was performed separately. As can be seen in Columns 2–4, digital literacy has a positive and significant effect on the total income of urban and rural individuals at a 1% level of significance; however, the impact is insignificant in the estate sector; therefore, when all other variables are held constant, the monthly income difference between digitally literate and digitally illiterate individuals in the urban sector is Rs. 20,887, with this amount higher in the rural sector (Rs. 26,393).

Respondents are classified into two groups based on their years of education to perform the next sub-sample analysis. Because of the upper ceiling of the senior secondary level of the Sri Lankan education system (before entering the Collegiate level), 11 years of education is taken as the basis to classify “low education” (less than 11 years) and “high education” (greater than or equal to 11 years), to perform the sub-sample analysis. The results of the sub-group regression analysis for the level of education are reported in Table 5. As can be seen in Columns 5 and 6, digital literacy has a significant positive effect (at a 1% level of significance) on the total income of individuals in both sub-samples; therefore, when all other variables are held constant, the monthly income difference between digitally literate and digitally illiterate individuals is Rs. 20,164 in the low education group, and the income difference is Rs. 27,350 in the high education group.

5. Discussion, conclusion and recommendations

5.1 Theoretical implications

The main theoretical implication of the present study can be articulated through the Digital Literacy Development Model proposed by Sharpe and Beetham (2010). As explained earlier, the initial phase of gathering digital literacy (*Access*) involves acquiring access to digital technologies and awareness. As per the findings, the access divide is high in Sri Lanka. For example, over 60% of Sri Lankans do not use a computing device, while internet usage is 33% among individuals. Many reasons could explain this, such as affordability issues, employability type, employment status and infrastructural issues impacting connectivity. Policies must address these disparities in access and awareness to ensure income opportunities. The second level of the model (*Skills*) emphasizes the impact of an individual's skills on developing digital literacy. As per the findings, education has a combined impact on an individual's income, showing better opportunities to participate in the gig economy through digital skills and enhancing income levels. *Practice* (the third level of the model) is vital in a digital economy because it has the potential to translate digital skills into tangible outcomes. Findings indicated that digital literacy and employment status have a combined impact on total income; therefore, it is imperative to incorporate digital tools into everyday transactions to enhance productivity and foster economic benefits. Finally, personal and societal identities should be taken into consideration in the *Identity* phase of the framework. Government and policymakers play a huge role in the Digital Literacy Development Model's final stage, enabling individuals to see themselves as contributors to the digital economy.

5.2 Implications for policymakers

The findings of this study identified several critical events that require attention. In general, the results show that digital literacy has a significant positive impact on the total income of Sri Lankan individuals. These empirical findings are consistent across various models that are employed in the current study as well as in existing literature. According to the data analysis, it can be revealed that more than 60% of Sri Lankan individuals do not use a computing device; therefore, the access divide is significantly high across the country. Moreover, this first-level digital divide (access to a computing device) is even more pronounced in the rural and estate sectors, with the main reason possibly being affordability issues. Furthermore, the majority of Sri Lankan households (77%) use smart/mobile phones

to connect to the internet/email instead of a desktop or a laptop computer. At the same time, internet usage among individuals is only approximately 33%. This internet usage rate is even lower among people in the estate sector (13%). Many reasons could explain this, such as affordability issues, employability type, employment status and infrastructural issues impacting connectivity. Hence, to reduce disparities, it is crucial to develop and enhance infrastructural facilities to access high-speed, reliable internet connection and digital resources at a lower cost. Furthermore, the analysis of the sources of computer knowledge attained by computer-literate households revealed that the primary source of computer literacy in Sri Lanka is schools/universities (59%). Hence, it is paramount to initiate programs for those unable to qualify for university education and senior citizens. For instance, one-to-one training and awareness can be arranged when people are required to use technology, such as at banks, supermarkets and government organizations.

As per the findings, digital literacy significantly positively impacts the total income of Sri Lankan individuals. This is confirmed by the various types of analyses used in the study, such as the IV model, logit model, combined effects and heterogeneity analysis. Results noticeably indicate that the major individual demographic characteristics, such as age, gender, location (residential sector), education, employment status and digital literacy, have a significant combined effect on the total income of an individual. The total income difference decreases with an individual's age due to the combined effect of age and digital literacy, possibly because digital natives are born with improved digital technology, enabling them to explore more opportunities, such as online entrepreneurship and online business opportunities. However, it shows a decreasing income difference with the age increase, possibly due to the unwillingness to take advantage of employment prospects on digital platforms due to a lack of knowledge of digital migrants.

Interestingly, the results show that the total income level of a digitally literate person decreases with the level of education. A few plausible explanations are that a growing trend exists among Sri Lankan early school leavers to engage in online business activities, including online entrepreneurship, through digital platforms and early career prospects that arise because individuals who leave school at an early stage receive ICT training, enabling them to earn a higher income than their counterparts. Therefore, the opportunity cost of more education is high for a digitally literate person in Sri Lanka. The Sri Lankan Government and other organizations have introduced many initiatives to upskill the youth of the country in digital literacy, especially in coding and robotics. The main objective of those programs is to equip the youth with a set of digital skills aligned with current workforce expectations. Because the income difference between digitally literate and digitally illiterate individuals in the high education group is significantly high and the income difference is low when the number of years of education increases, the Sri Lankan higher education sector should identify the requirements of the corporate world and the employers to focus on enhancing digital literacy. The pursuit of advanced education in ICT has the potential to offer individuals the chance to obtain offline benefits from online activities, thereby alleviating digital and income inequalities. Ultimately, digital learning, digital skills and knowledge and digital teaching and learning practices accelerate progress towards the ultimate goal of SDG 04: Inclusive and quality education for all.

The results further show that the residential sector of an individual, in conjunction with their digital literacy, have a significant combined impact on total income. This income difference is higher among individuals in different sectors, such as when comparing urban with rural and urban with estate. The limited availability of employment opportunities for digitally literate people and the lack of other sources of income in these rural areas of Sri Lanka are the potential reasons for these inequalities. In response to this, policies should be implemented to develop human capital through ICT by explicitly focusing on small and medium-scale enterprises and online entrepreneurs, especially in the rural and estate sectors of Sri Lanka. Moreover, speed, reliable and affordable connectivity to the internet,

and equal distribution of ICT infrastructure among all sectors are crucial when promoting equality in a digital economy.

Additionally, the results show that percentages in the categories of device and internet usage among female individuals are lower than those of their male counterparts. Although not a significant difference, policies should be introduced to prioritize women when implementing ICT training to reduce digital disparities, especially in the work environment. Women, however, may exhibit a reluctance to adopt digital technology for various reasons, including concerns related to the affordability of equipment and possible risks associated with the usage of computer devices, such as cybercrimes and online violence. This has the potential to result in the further exclusion of women from participation in the digital economy, hence exacerbating gender-based disparities. Furthermore, the combined effects analysis shows a significant income difference between males and females; therefore, excluding women from digital participation restricts their access to a wide range of crucial benefits the digital economy offers, including online healthcare services, online education and online financial services. Hence, the implementation and advocacy of targeted initiatives aimed at enhancing digital literacy among women in public and workplace settings can effectively mitigate gender-based digital inequities, counteract detrimental gender stereotypes, and foster the empowerment of women within the digital economy. All of these will ultimately help Sri Lanka to achieve SDG 5: Achieving gender equality and empowering all women and girls.

Because digital literacy and employment status have a combined impact on total income, it is paramount that the various employment types and statuses be aligned with 21st-century skills, including digital skills, to establish an ICT and knowledge-based workforce and society. To increase digital literacy among permanent employees, employers can introduce training programs and workshops on digital skills as part of their continuous career development programs. To reduce digital and income inequalities, the Sri Lankan Government and policymakers should pay special attention to enhancing digital infrastructure and digital skills across the country. One crucial step that the Sri Lankan Government should implement is policy-level decisions to include a digitally skilled community in the labour force. Over the past decade, different governmental and non-governmental institutes have examined the issue of digital disparity and sporadically introduced several programs to enhance digital participation. However, it is imperative to prioritize the comprehensive use of online resources by online users to enable them to engage fully in the digital economy. When designing training and awareness programs to enhance digital skills, ensuring this use can help foster meaningful connectivity and identify the diverse digital competencies required by different communities and occupations. These training programs, as well as services introduced by the government and related organizations, should be specifically focused on communities that require a solution. Otherwise, benefits may be directed to one segment of the community, potentially worsening existing digital and economic inequities and creating a major obstacle in achieving sustainable development.

6. Limitations and future research

Despite using multiple empirical models to comprehensively analyse the multifaceted impact of digital literacy on the total income of individuals in Sri Lanka, this study has certain limitations. Firstly, the definition of digital literacy used by the DCS Sri Lanka, which considers only the ability to use computers, laptops, tablets and smartphones as constituting digital literacy, is inadequate in its scope. In the present digitalized setting, the concept of digital literacy encompasses more than just the basic use of computing devices; it involves a combination of various dimensions. Secondly, the data set used in this study consisted of only nine items pertaining to digital literacy, which does not adequately capture the comprehensive nature of the impact of digital literacy on income. Third, the endogeneity issue needs to be analysed further and solved. Finally, the combined effects of digital literacy on total income could be further explored using more variables to investigate further

impacts and relationships. Future researchers could also potentially use these limitations as directions to carry out further in-depth studies in the same field.

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