



The Interrelationship Between Digital Access and Modern Slavery

Mohamad Ali Safieddine¹ · Suman Lodh² · Monomita Nandy¹ · Katherine Leanne Christ³ · Roger Leonard Burritt⁴

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Abstract

This study examines the relationship between country-level digital access and vulnerability to modern slavery, focussing on countries committed to achieving United Nations Sustainable Development Goal (SDG) 8.7. The study draws on information poverty theory to frame analysis of the role of digital connectivity as a moral good in reducing modern slavery exploitation risks. Using panel data from 31 OECD countries over a 10-year period, the research tests two hypotheses on the relationship between digital access, governance, transparency and modern slavery vulnerability. The findings reveal that greater digital access is associated with lower vulnerability to modern slavery and that this effect is significantly shaped by the quality of national governance and transparency. Based on information poverty theory, the study expands the understanding of modern slavery vulnerability by demonstrating how digital access influences exploitation risks within the governance framework, risks that the state has a moral duty to reduce. The findings provide insights for policymakers and business leaders, emphasising the importance of digital inclusion and transparent governance in reducing modern slavery and strengthening human rights protections.

Keywords Digital access · Information poverty theory · Moral good · Modern slavery vulnerability · Country governance · Transparency · Reducing modern slavery · Sustainable development goal 8.7

Introduction

Extreme exploitation in the workplace is a hallmark of modern slavery and is well captured by the characteristics of forced labour, defined by the International Labour Organisation as being “...all work or service which is exacted from any person under the menace of any penalty and for which the said person has not offered [themselves] voluntarily” (ILO, 1930, Article 2.1). Discussion amongst academics and professionals about examining and assessing ways to mitigate modern slavery, which includes forced and bonded labour, the worst forms of child labour as well as human trafficking, is on the increase (Christ & Helliard, 2021). Existing researchers acknowledge that modern slavery is a global problem and as a practice is hard to bring to an end, so it may be more pragmatic in the short-term to try to reduce vulnerability to the practice (Bouguerra et al., 2023; Caruana et al., 2021; Christ et al., 2020). In response to the challenge set down by Reiner et al. (2025) and Walk Free (2023), this research develops a causal theory that can help inform variable selection to predict and help reduce modern slavery vulnerability (MSV). It examines how key digital issues, such as internet accessibility, use of technological devices,

✉ Suman Lodh
s.lodh@kingston.ac.uk

Mohamad Ali Safieddine
msafieddine8@gmail.com

Monomita Nandy
monomita.nandy@brunel.ac.uk

Katherine Leanne Christ
katherine.christ@adelaide.edu.au

Roger Leonard Burritt
roger.burritt@anu.edu.au

¹ Brunel Business School, Brunel University of London, Kingston Lane, Uxbridge, Middlesex UB8 3PH, UK

² Kingston Business School, Kingston Hill Campus, Kingston University London, Kingston Upon Thames, Surrey KT2 7LB, UK

³ School of Accounting and Finance, College of Business and Law, Adelaide University, Level 12, 10 Pulteney Street, Adelaide, SA 5000, Australia

⁴ Fenner School of Environment and Society, College of Systems and Society, The Australian National University, Canberra, ACT 2601, Australia

digital access subscriptions and education are related to the moral duty of states to reduce MSV which potentially leads to worker exploitation and modern slavery.

There is an increase in modern slavery research; however, empirical examination of the factors affecting vulnerability to exploitation is absent (Szablewska & Kubacki, 2023). Although current scholarship examines vulnerability in a qualitative way, it does not provide empirical insight as to how vulnerability to modern slavery can be reduced at the country level (Han, et al., 2024). This association has not been systematically examined at a national scale within peer-reviewed literature. Thus far, the only notable attempt to address this link appears in the two reports by the Walk Free Foundation (2018; 2023), which employ modelling rather than empirical analysis. Consequently, there remains a significant gap in academic literature regarding how digital access may influence vulnerability across countries. This research addresses the gap in the modern slavery discourse by providing empirical insights into the interplay between digital access, governance mechanisms and transparency in shaping vulnerability.

To date, much of the focus on combatting modern slavery has been concerned with the development and adoption of transparency and/or due diligence-based modern slavery legislation aimed at the business sector by encouraging improved engagement with modern slavery risk management and mitigation in direct operations and supply chains (Andersson et al., 2018; Christ & Burritt, 2025; Ford & Nolan, 2020). Transparency is seen as a crucial ethical factor for corporations to avoid reputational damage (Qian et al., 2015; Vaccaro & Patiño Echeverri, 2010). Despite this, there are doubts about the effectiveness of transparency policies in disclosing non-financial information (Chauvey et al., 2015), especially in modern slavery reports, which often remain symbolic (Pinnington et al., 2023). Indeed, this seems to be the preferred approach emanating from developed Western countries. The idea is that large companies, with complex supply chains, can use their reputations and market power to put pressure on suppliers and address what is essentially a transnational problem beyond the ability of any one national government to resolve (Zhang et al., 2023). Whilst Crane (2013) identifies the possible importance of the socio-economic context, including education and awareness, poverty and unemployment, and the strength of governance, no empirical evidence is provided. There appears to be no empirical evidence about the contribution that individual countries make to reducing modern slavery vulnerability and this is addressed here for the first time in the context of digital access.

Digital access can be defined as having access to appropriate, adequate and affordable information and communication technology infrastructure, and the ability to understand and navigate such infrastructure (Matli & Ngoepe, 2021).

It is a precondition for autonomy, enabling individuals to understand risks, access help, and make informed choices. Previous research suggests that when people do not have such access, they can find themselves in what is known as information poverty and this can, in turn, influence social outcomes (Buchanan & Tuckerman, 2016). Furthermore, information poverty can lead to information injustice and moral harm (Britz, 2004), whereas digital access can expand human agency and reduce structural vulnerability (Humanitech & Australian Red Cross, 2020). The implication is that states and businesses should consider a duty of care to create conditions where digital access can meaningfully protect citizens and vulnerability be reduced. In Asokan et al. (2022), there is an indication of the importance of digital access in socially responsible corporate operations. In addition, Malpass et al. (2022) examine the benefit to survivors of modern slavery in having access to a smartphone. In the Covid-19 pandemic they find benefits resulting from free access, with unlimited data, and emotional costs of digital inclusion. However, other studies argue that the relationship between digital access and modern slavery vulnerability is more nuanced than it appears. For example, Enrile and Aquino-Adriatico (2024) and Idowu (2024) indicate that contemporary information and communication technologies can be used by criminals to further exploit victims. To date, other than in the Walk Free Foundation's (2018) modelling, the literature has offered only limited empirical insight into the statistical association between digital access and vulnerability to modern slavery. If such a link could be established, it might be used to aid the development and success of interventions at government and corporate levels, both of which are needed if UN SDG 8.7¹ is to be successfully realised. This lack of current knowledge leads to the following research questions (RQs):

RQ1: In what way does access to digital communication technologies, along with a country's transparency level, impact vulnerability to modern slavery?

RQ2: In what way does access to digital communication technologies, along with country governance, impact vulnerability to modern slavery?

To understand the issue of digital access the lens of information poverty theory is used (Buchanan & Tuckerman, 2016). Information poverty theory seeks to understand and influence information behaviours in disadvantaged socio-economic as well as disengaged education and employment circumstances of individuals. The data analysis

¹ UN SDG 8.7 urges international community to eradicate all forms of child labour and end modern slavery and human trafficking (MSHT) by 2030.

further combines factors such as country governance and level of transparency to understand better how the relationship between digital access and vulnerability manifests in practice.

The paper proceeds as follows: Sect. “[Literature and theoretical foundations](#)” outlines the problem of MSV and the theoretical framework to be used. Sect. “[Development of hypotheses](#)” develops two hypotheses for testing, whilst Sect. “[Methods](#)” details the research method used to gather evidence in relation to testing the hypotheses. Results of the empirical investigation are revealed in Sect. “[Results](#)”. This is followed in Sect. “[Discussion](#)” by a discussion and concluding comments about the implications for theory, management and policy makers, future research and limitations of the study. Sect. “[Conclusion](#)” provides a short conclusion.

Literature and Theoretical Foundations

Modern Slavery and Modern Slavery Vulnerability

Current estimates suggest there are presently more than 50 million people living in modern slavery conditions worldwide (ILO, Walk Free & IOM, 2022). To date, there is no universally agreed definition of modern slavery, however from a business perspective it is said to include forced labour, debt-bonded labour, the worst forms of child labour and human trafficking (Christ & Burritt, 2021). Of the total estimated number of victims, it is suggested that 28 million people are currently in forced labour, with 86% of these associated with the business and private sector and the remaining 14% trapped in state sanctioned forced labour (ILO, Walk Free & IOM, 2022).

Although businesses may not be directly involved with modern slavery, many are indirectly supporting the practice via their global supply chains (Meehan & Pinnington, 2021). This partly explains the increase in modern slavery-related legislation directed at business in recent years. In 2024 the illegal profits generated from modern slavery were estimated to be in the region of US\$236 billion per annum (ILO, 2024), an increase from US\$150 billion in 2014 (US\$172 billion inflation adjusted).

These figures are shocking to read and highlight the scale that the problem of modern slavery presents for both society and the business sector. Recognition of this problem has led to a plethora of research on modern slavery that has emerged in recent years (Birkey et al., 2018; Meehan & Pinnington, 2021; Pinnington et al., 2023). This research mainly considers modern slavery from the perspective of focal companies and is concerned with how large, multinational enterprises can be encouraged to engage with their supply chains to improve practices and conditions for workers in other, often less developed, countries with which they have supply

arrangements (Caruana et al., 2021; Stringer & Michailova, 2018). However, relying solely on large multinational companies to use their market power to bring about change is problematic as modern slavery is a multi-tiered supply chain issue that is difficult to track and trace and is often associated with poverty, discrimination, and other systemic socioeconomic issues that are beyond the ability of corporations to address (Hess, 2021). Thus, whilst research that considers the role of large focal companies in supply chains is both important and needed, there is a parallel need to protect at-risk populations from exploitation by decreasing their vulnerability to modern slavery. If SDG 8.7 is eventually to be realised, research concerned with addressing the problem at the level at which victimisation occurs is equally important.

Vulnerability can be succinctly defined as the quality of being exposed to the possibility or state of being attacked or harmed, either physically or emotionally (Concise Oxford English Dictionary, 2008). People get into positions where they can become, or they are, victims of modern slavery. Thus, if the practice is to be ended by 2030, as is the aspiration of United Nations Sustainable Development Goal (SDG) 8.7 and the 179 member countries that signed up to achieve the goal, it is a duty of states to reduce vulnerability (UN, 2015).

Although modern slavery takes many forms, forced labour is the type of exploitation that receives the most attention (Gutierrez-Huerter et al., 2023; Rioux et al., 2020). In addition, it has been observed that when it comes to international intervention, identification of victims and assessing and managing vulnerability of potential victims are second in importance only to corporate supply chain risk (Hilland et al., 2022). Hence, the importance of addressing vulnerability is well established. Indeed, given the anticipated pervasiveness of modern slavery, in 2018 the Walk Free Foundation developed a Global Slavery Index Vulnerability Model to measure the prevalence of vulnerability in different countries around the world. The model was a key input to a Global Slavery Index used to help assess government responses and guide policies and action on modern slavery.

The model, based on human security and crime prevention theories, “provides a risk score for 167 countries based on an analysis of data covering 23 risk variables across five major dimensions” (Walk Free Foundation, 2018, p. 10). The five dimensions associated with the prevalence of modern slavery included in the model are governance issues, lack of basic needs, inequality, disenfranchised groups and effects of conflict. From a digital access perspective, lack of basic needs includes cell phone users as one digital access risk variable in the vulnerability score, but internet usage was excluded as, although it was once available, the World Bank (WB) stopped gathering this data in 2018.

Kubacki et al. (2024) concur with the position taken by the Walk Free Foundation stating that vulnerability to

modern slavery is exacerbated by macroeconomic and social concerns and these need to be considered in all actions taken to combat the practice. The authors further argue that building resilience at the level of individual workers is one way vulnerability can be reduced, but that research concerning how this might be achieved is underdeveloped. Heywood and Vaughn (2024) build on this argument by suggesting that financial inclusion offers one way resilience can be built and vulnerability overcome. However, they also note such inclusion may be difficult to achieve if digital technologies are not available. In contrast, Enrile and Aquino-Adriatico (2024) suggest technology is a part of the problem as it has increased the reach of those who seek to exploit and victimise people for financial gain. Yet even these authors recognise how technology might be used to fight back against criminals. More specifically, the collaboration *Tech Against Trafficking* is discussed as having potential to disrupt existing criminal activity. The role of digital disruption is supported by Christ and Helliard (2021) who suggest newer technologies offer potential to reduce vulnerability to modern slavery. Finally, Idowu (2024) demonstrates how access to information technology can exacerbate and alleviate exploitation and marginalisation of African female domestic workers in the Middle East.

These studies outlined present a fragmented picture concerning whether modern communication technologies increase or decrease vulnerability. In consequence, the first research question has a focus on the impact of access to digital communication technologies on modern slavery vulnerability.

Information Poverty Theory

It is widely recognised that people who are information poor are more vulnerable than those with relevant information and can be open to greater manipulation, such as by those adopting modern slavery business practices (Buchanan & Tuckerman, 2016). Information literacy is vital for managing and coping with critical life situations (Martzoukou & Abdi, 2017) such as those thrown up by modern slavery. Buchanan and Tuckerman (2016) examine the absence of information literacy on disadvantaged and disengaged adolescents and the way tailored solutions and interventions can be developed to help them overcome such information poverty and social vulnerability. Amongst other factors, they found such adolescents to be favourably influenced by phone and online activities such as email and messaging technologies.

Similar solutions and interventions are desirable for people who do, or may, unexpectedly become victims of

modern slavery. In an analogous situation, Martzoukou and Abdi (2017) refer to people fleeing to a new country because of war/natural disasters² or unemployment and the importance of information and literacy to addressing critical life issues arising. Information about such new, uncertain circumstances needs to be rapidly acquired and assessed. Martzoukou and Abdi (2017) provide the example of refugees who, because they do not have the skills to handle overwhelming and contradictory information about their situations, succumb to becoming jobless, homeless, disabled, or socially vulnerable. Information poverty theory suggests the need for information intermediaries to provide dynamic support to marginalised individuals that are oppressed or susceptible to harm (Buchanan et al., 2019; Nicol et al., 2022). This makes information poverty theory of potential interest as a guide to reducing vulnerability of modern slavery victims. Based on this theoretical understanding, it can be argued that digital access will reduce vulnerability to modern slavery. However, there is also evidence suggesting that the relationship is not always clear-cut. Thus, it becomes important to understand other factors that might impact this relationship. In this context, the analysis presented here also considers country governance and transparency.

Transparency and Country Governance

Transparency about modern slavery risk involves attempts to improve visibility of actions through internal, supply chain and external disclosure with the purpose of ending practices such as forced labour, extreme forms of child labour and bonded labour (Bai et al., 2022). Transparency requires tools to track and trace data throughout business operations and their multiple supply chain tiers. In practice, in the absence of success to reduce or end modern slavery in the last hundred years (ILO, 1930; 2024), legislation has been introduced. At this point in time, legislation is largely in developed countries, to increase external disclosure about modern slavery risk and its remediation by large companies (e.g. Australia, Canada, France, Germany, Norway, Switzerland, the UK), parts of countries (e.g. California) and regions (e.g. the European Union) (Albitar et al., 2025; Szablewska & Kubacki, 2023). The hope is that greater legislated transparency will trickle down into lower tiers in business supply chains and bring pressure to reduce modern slavery. Nevertheless, in the vast majority of countries there are no such requirements to disclose information about modern slavery practices, with reliance being placed instead on voluntary tools to change business behaviour, such as through supplier codes of conduct (Szablewska & Kubacki, 2023).

Transparency and country governance are interrelated with both being notions linked to accountability (Albitar et al., 2025; Whittington & Yakis-Douglas, 2020). Deliberative governance relies on legal imposts such as the rule of

² <https://www.walkfree.org/news/2024/modern-slavery-risks-rise-as-greatest-number-of-global-conflicts-since-wwii/>

law to implement transparency, control of corruption and government effectiveness to achieve its policies. Higher transparency and higher levels of governance in countries demonstrate situations where it is easier to hold businesses to account. Where legislation requires greater transparency about modern slavery practices and is enforced, internal and external parties are better advised about modern slavery risk and its mitigation. Being able to reduce modern slavery vulnerability, through more effective country governance and transparency, would be a useful policy tool for governments and business. Nevertheless, greater transparency through digital access is not just a feature of national governance but a moral obligation grounded in accountability and respect for persons.

Development of Hypotheses

Given the theoretical foundation provided by information poverty theory, where actors in the modern slavery ecosystem operate at direct and indirect levels to the victims in corporate operations and supply chains, two hypotheses are developed.

The eventual ending of modern slavery has been given a high place on the United Nations SDGs agenda, yet recent estimates from the ILO, Walk Free, and IOM (2022) indicate the problem is getting worse. Indeed, it is suggested there are currently 10 million more people in modern slavery since 2018, the previous time a global estimate was calculated (ILO, Walk Free & IOM, 2022). One possible reason is that current mechanisms, such as required corporate reporting in some countries, are not working (Burritt & Christ, 2023). Another possibility, as examined here, is that vulnerability has increased because of ongoing information poverty. Understanding vulnerability is just one aspect of the larger concern of managing modern slavery with a view to eventually ending the practice, as envisaged in the United Nations SDGs.

It is possible that lack of digital access to information will provide a roadblock to implementation of initiatives aimed at ending modern slavery (Malpass et al., 2022). Lack of digital access acts to reinforce information poverty and increases individual vulnerability to modern slavery. Vulnerability increases the likelihood of individuals falling into modern slavery and as a result it is positioned as a roadblock to the reduction of modern slavery.

To remove this roadblock, it is necessary to consider how to change the actions and situations to reduce vulnerability. Information poverty has been discussed in the information science literature for decades (Marcella & Chowdhury, 2020). When people lack access to information, which is now acknowledged as being a fundamental human right (Worthy, 2017), they can become disadvantaged in other

ways as they may be unable to evaluate opportunities and improve their fortunes. Closely aligned with the concept of information poverty and in many ways exacerbating it, is the digital divide between countries (Gebremichael & Jackson, 2006). This is interesting given some have argued that technology-based approaches might provide a powerful tool in combatting MSV and improving conditions for workers and low-income entrepreneurs in developing countries (Christ & Helliar, 2021; Neumeyer et al., 2020; Taylor & Shih, 2019). Indeed, Gebremichael and Jackson (2006, p. 269) argue that lack of information and communications technology (ICT) infrastructure and digital access can lead to entire nations being ‘denied the possibility of economic and social growth’. May (2012) is more cautious, suggesting that although there might be a link between the use of ICT and reduced poverty and improved welfare, the nature of the link is not well understood. In the context of reducing MSV in line with SDG 8.7, transparency also matters. Transparency is the core of most modern slavery reporting legislation (Pinnington et al., 2023) and is regarded as being essential to achieving ethical and moral changes in behaviour management practices (Doorey, 2011). As such, this leads to the following hypothesis:

H1: *Digital access to communication technologies is negatively associated with modern slavery vulnerability in countries with high transparency.*

Caruana et al. (2021) suggest that the majority of research considering the supply side of modern slavery has focussed on the link between factors such as poverty, socio-economic conditions, migration status, labour protections and vulnerability to modern slavery and exploitation. In relation to developing countries, it has been argued that for people who live on US\$1 a day the direct costs of digital access exceed the benefits and government intervention through improved broadcasting would be a better way to reduce vulnerability (Ahmed, 2007; Kenny, 2002). However, to the authors’ knowledge, there has been no country-level research that considers the potential link between digital access and vulnerability to modern slavery. This omission is surprising given some researchers suggest access to information and MSV are linked and the observation that most information today is provided via digital means (e.g., see Gezie et al., 2019; Thinyane et al., 2020). Furthermore, guidance such as that provided by the Australian Government in relation to the Modern Slavery Act (2018) (Cth), suggests that businesses should ensure workers in their supply chains have access in their own languages to information about their rights, obligations and ways to seek support, if needed (Australian Government, 2019). Available literature on information poverty helps to understand why the connection between digital access and vulnerability is potentially important for

policy makers and implementers and for contributing to the ending of modern slavery.

Within this context, modern slavery provides one facet of vulnerability associated with poverty in which the role of technology and digital access has not been fully explored. Whilst evidence suggests that school education helps reduce child labour, absence of digital access via the internet for those at school also puts children into more vulnerable positions (Bilal, 2010; Das, 2022; Mohammed, 2022) and, thus, at risk from its extreme forms. There is a clear need to extend research which considers how digital access, and different information and communications technologies, impact (or not) vulnerability to modern slavery. In addition, governance in a country has an impact and plays a vital role in MSV context. Better governance helps countries to develop faster and better use their resources efficiently and make them available to help society's most vulnerable (Jindra & Vaz, 2019). In order to understand this link better, the following hypothesis is proposed:

H2: *Digital access to communication technologies is negatively associated with vulnerability to modern slavery in high governance countries.*

These hypotheses will help garner a better understanding of the factors associated with the problem of vulnerability to modern slavery. With better understanding it will then be possible to make recommendations regarding possible changes to bring about better outcomes both for individuals involved in modern slavery and for businesses that are open to modern slavery risks (Christ & Burritt, 2025).

Methods

Sample

Szablewska and Kubacki (2023, p. 9) suggest that “A better understanding of the implications of legal and regulatory regimes on countries beyond where the specific laws have been passed would significantly improve comprehension of the barriers and catalysts in addressing modern slavery in supply chains globally.” With this in mind, for the data sample, digital access information and MSV constituent indicators are obtained from the World Bank database for 31 member states of the Organisation for Economic Cooperation and Development (OECD), which contains a mix of countries with modern slavery legislation and those without. The countries included in the analysis are Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain,

Sweden, Switzerland, Turkey, the UK, and the USA. The final sample covers the period between 2010 and 2019 and consists of 310 country-year observations. The selection of variables follows the Asokan et al. (2022) and Walk Free Foundation (2018) who indicate the importance of technology and digital access in discussions about modern slavery and the absence of empirical evidence in this area. Also, the ILO, Walk Free and IOM (2022) rank expanding workers' voice and extending social protection to workers in situations of vulnerability as the top two priorities for ending forced labour. Thus, the study examines the impact of digital access on MSV.

Variable Description

The dependent variable adopted is MSV, which reflects how susceptible a country is to having modern slavery and is measured through the indicators and targets of SDG 8 (Murray et al., 2022). MSV is defined to be constituted from employment in the agriculture and services industries, where modern slavery is highly prevalent (ILO, Walk Free & IOM, 2022; Walk Free Foundation, 2018;). Moreover, education accessibility for youth plays a role in eradicating modern slavery (Walk Free Foundation, 2018), as well as unemployment which increases vulnerability of individuals to exploitation (Christ & Burritt, 2021). As such, measurement of the vulnerability for modern slavery is proxied through the SDG 8.7 targets.

The independent variable adopted is the digital access index (DAI) indicators. Digital technology plays a role in implementation and attainment of the SDGs (Janowski, 2016). The DAI is constituted from five broad classes related to infrastructure, affordability, level of education, information quality, and usage of the internet (Alper & Miktus, 2019; ITU, 2005). In addition, each class contains various indicators, such as mobile phone, fixed landline, and broadband subscriptions, secured servers, internet users, and school enrolment, which collectively capture and measure digital access (Barzilai-Nahon, 2006; Alper and Miktus (2019).

Principal component analysis (PCA) is used here as it is acknowledged to be a robust statistical technique to combine two overlapping factors into one and decrease noise (Hoitash et al., 2012; Gull et al., 2018; Paoletta, Polak & Walker, 2021). The core of this approach is to decrease the loss of information to a minimal level (Capelle-Blancard et al., 2019). Since the dependent and the independent variables are captured and constituted from different factors, PCA is used to calculate a principal component score based on those factors. Following the literature, for MSV, those factors are the SDG-8-related targets (Murray et al., 2022) such as employment in the agriculture and services industries (ILO, Walk Free & IOM, 2022), unemployment and

youth unemployment (Christ and Burritt, 2021), and youth not in an educational system (Walk Free Foundation, 2018). As for the independent variable, DA, the factors listed by Alper and Miktus (2019) and ITU (2005) are mobile phone, fixed landline, and broadband subscriptions, secured servers, internet users, and school enrolment (average of primary, secondary and tertiary enrolment), which collectively capture and measure digital access (Barzilai-Nahon, 2006). For the suitability of these two main variables, MSV and DA, the necessary diagnostic tests have been conducted. Kaiser–Meyer–Olkin (KMO), the measure of sampling adequacy, is 0.601 for MSV and indicates a modest sampling adequacy. Bartlett’s test of sphericity is significant ($\chi^2(10) = 1197.175$, $p < 0.001$) suggesting that the correlation matrix is significantly different from an identity matrix. The analysis yields a single component explaining 56.47% of the total variance. On the other hand, KMO for the DA variable is 0.51 which is low but above the recommended PCA threshold of 0.50 (Cerny & Kaiser, 1977). The Bartlett’s test of sphericity for DA is significant ($\chi^2(15) = 566.145$, $p < 0.001$). The rotated component matrices yielded satisfactory composite loading scores that exceeded acceptable thresholds, confirming construct adequacy. The transparency index, obtained from the Transparency International website,³ is also included in the model. Transparency is the core of most modern slavery reporting legislation (Pinnington et al., 2023). The transparency index (also termed the “Corruption Perceptions Index”) captures the level of corruption amongst public officials in a country (Kemme et al., 2020). Transparency is essential to achieving ethical and moral changes in behaviour (Doorey, 2011), through a procedure where corporations fear some corporate actions may lead to a damaged reputation (Rogerson et al., 2020).

Country-level governance factors are included, constructed as average country governance following Lodh et al., (2023: page 4274). It is derived from the Worldwide Governance Indicators (hereafter WGI) DataBank website.⁴ Governance indicators reveal the risks of corporations in countries having issues with their legislation process and/or in their political system (Klapper & Love, 2004). According to Moussa et al. (2022), strong governance structures act as motivators and exercise pressures on corporations to adopt ethical behaviours and practices and be more compliant with the regulations, thus minimising the modern slavery risk levels. Previous researchers suggest that higher levels of governance indicators are negatively linked with modern slavery, for example, a negative impact of higher levels of democracy and voice and accountability on slavery

vulnerability levels (Landman & Silverman, 2019). Moreover, political stability and lower rates of crimes are said to be negatively related to modern slavery risks (Bales, 2007). Moussa et al. (2022) find that countries with high governance, high levels of law enforcement and rule of law, more transparency, accountability, and monitoring reduce the risk of modern slavery and its vulnerability. Economic factors which are widely used in related literature are controlled. For example, Lucas and Landman (2021) find that higher GDP growth significantly lowers vulnerability to modern slavery. In addition, Lochner (2020) argues that better education reduces the possibility of unemployment, which is associated with increasing crime rates, which in turn is linked to MSV and risk. According to the International Organisation for Migration (IOM, 2017), affected people may resort to risky and informal, even illegal, ways and networks to relocate, putting themselves in positions of high vulnerability to being trafficked and exploited for forced labour purposes. Population growth and inflow from foreign populations are controlled, as well as inflation. Details about the full list of variables and the sources of data are included in Table 6 in Appendix.

Results

Data Description

Summary statistics are exhibited in Table 1. The mean values of the dependent and the independent variable, MSV and DA, are not shown in the table because they are constituted from different factors from across the countries during the time period. The table reports the skewness and kurtosis of the variables. The Shapiro–Wilk and Kolmogorov–Smirnov tests are used to check for normality. These tests show that the residuals and several explanatory variables are not normally distributed. This is expected as the data comes from multiple sources and spans multiple years and countries. However, this does not invalidate the OLS estimates. As noted by Greene (2019), the normality assumption is not required for OLS consistency, and large-sample inference remains valid even when the error terms or independent variables deviate from normality. Similarly, Cameron and Trivedi (2005) emphasise that OLS continues to possess desirable asymptotic properties under non-normality when robust variance estimators are used. Therefore, despite the lack of normality in the residuals, the reported OLS results remain reliable and appropriate for conclusion as the estimations in all the regression models are based on White’s heteroskedasticity-consistent standard errors.

In addition, the correlation matrix of the variables included in the study is shown in Table 2. The correlation between MSV and digital access supports the argument that

³ www.transparency.org

⁴ <https://www.worldbank.org/en/publication/worldwide-governance-indicators>

Table 1 Descriptive statistics of variables

Variables, $n = 304$	Mean	Std. Dev	Min	p50	Max	Skewness	Kurtosis	Joint Skewness and Kurtosis: Prob > Chi ²
Modern slavery vulnerability	–	1.68	–2.46	–0.42	5.43	0.90	3.41	0.00
Digital access	–	1.52	–4.94	0.28	5.34	–0.47	3.89	0.00
Avg. country governance	1.15	0.59	–0.49	1.24	1.92	–0.85	3.36	0.00
Transparency	6.86	1.67	2.80	7.20	9.50	–0.57	2.35	0.00
Inflation	1.94	2.25	–2.98	1.52	16.48	2.32	13.93	0.00
Population growth	0.55	0.74	–2.08	0.48	2.68	0.03	4.06	0.04
Inflow of foreign population	1.83	3.00	0.01	0.70	20.16	3.05	13.24	0.00
GDP growth	2.27	2.59	–10.15	2.11	25.18	2.02	28.55	0.00

The values in Table 1 show the statistics describing the variables used in the models. modern slavery vulnerability (MSV) is the dependent variable. digital access (level of accessibility to digital technologies), Avg. country governance (the average of the 6 factors of governance: VoA, GE, RegQ, RoL, CoC, and PS), inflation (the level of inflation in a country in %), population growth (the level of population growing in a country in %), inflow of foreign population (in thousands, '000), transparency index (value showing the level of country transparency, between 0 being least transparent and 10 being most transparent), and GDP growth (the country's annual GDP growth, in %). The values of Skewness and Kurtosis, along with the joint p value test for normality are presented. Table 6 in Appendix shows the detailed definition for the variables in the study

Table 2 Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Modern slavery vulnerability	1.00							
(2) Digital access	–0.72***	1.00						
(3) Avg. country governance	–0.76***	0.76***	1.00					
(4) Transparency	–0.73***	0.75***	0.96***	1.00				
(5) Inflation	0.18***	–0.33***	–0.34***	–0.22***	1.00			
(6) Population growth	–0.32***	0.13**	0.27***	0.34***	0.27***	1.00		
(7) Inflow of foreign population	–0.16***	0.18***	0.07	0.12**	0.01	0.04	1.00	
(8) GDP growth	–0.09	–0.08	–0.02	0.03	0.35***	0.24***	–0.05	1.00

Table 2 shows the correlation matrix for all variables used in our models. The marks ***, **, and * represent the significance levels at the 1, 5, and 10%, respectively. Table 6 in Appendix shows the detailed definition for the variables in the study

digital access significantly and negatively impacts MSV. Also, the correlation between the MSV and average country governance, as well as the transparency index, is negative and significant. This indicates that an increase in digital access, better governance, and higher transparency reduces vulnerability to modern slavery.

Given the strong correlation between the transparency index and country governance (0.96), two separate model specifications are run, each containing one of these variables, similar to Haque and Jones (2020). First, the model is run with the average country governance followed by the transparency index. Second, following the literature, such as Gull et al. (2018), the two variables are combined into one (using PCA) to examine the combined effect of it on the dependent variable. Finally, the variance inflation factor (VIF) is checked to evaluate the presence of multicollinearity amongst the partitioned variables further. Untabulated VIFs for the independent variables are all smaller than 3.00,

which confirms that multicollinearity is not a serious issue in the analysis (Zuur et al., 2010).

For robustness checks, the two-stage least squares (2SLS) regression is conducted, with the results being unchanged. In summary, MSV is found to be lower when there is higher and better digital access, mainly in countries with a stronger governance structure and better transparency index. These results are consistent with existing literature.

Identification Strategy

To examine how digital access and associated average country governance and transparency affect the MSV in the OECD countries, a pooled OLS and panel data regression model is employed (Cameron et al., 2020). The MSV is strongly influenced by unobserved, country-specific characteristics such as legal system or social attitude that do not change within a short period of time. So, the panel data

regression helps to understand if and how digital access, country governance, and transparency factors affect MSV, and to see whether there is any impact on informational capabilities. In Eq. 1, the average country governance variable that varies with contemporary policy actions and external evaluations is included, thereby reducing correlation with country-level unobservable factors. The average country governance is replaced with the transparency index in Eq. 2 reflecting time-invariant institutional and political accountability mechanisms, as well as anti-corruption norms (Andersson & Heywood, 2009). A random effects model is justified because the unobserved country-specific characteristics that affect MSV are time invariant and reasonably assumed to be uncorrelated with transparency, country governance and the other independent variables. This allows the model to use both within- and between-country variation whilst keeping time-invariant controls in the model, resulting in more efficient estimates. The result of the Breusch-Pagan test confirms the presence of heteroscedasticity, which may arise from having incorrect and unspecific independent variables, and the presence of unequal variance of residuals of one variable affecting another. To address any heteroscedasticity concerns, robust standard errors are calculated for the models, following Huber–White heteroscedasticity. The two baseline models for estimations are as follows:

$$\begin{aligned} \text{MSV}_{it} = & \alpha + \beta_1 \text{Digital Access}_{it} + \beta_2 \text{AvgCG}_{it} \\ & + \beta_3 \text{Inflation}_{it} + \beta_4 \text{Population Growth}_{it} \\ & + \beta_5 \text{Inflow of Foreign Population}_{it} \\ & + \beta_6 \text{GDP Growth}_{it} + \gamma_t + \varepsilon_{it}, \end{aligned} \quad (1)$$

$$\begin{aligned} \text{MSV}_{it} = & \alpha + \beta_1 \text{Digital Access}_{it} \\ & + \beta_2 \text{Transparency Index}_{it} + \beta_3 \text{Inflation}_{it} \\ & + \beta_4 \text{Population Growth}_{it} \\ & + \beta_5 \text{Inflow of Foreign Population}_{it} \\ & + \beta_6 \text{GDP Growth}_{it} + \gamma_t + \varepsilon_{it}, \end{aligned} \quad (2)$$

where MSV is the modern slavery vulnerability in country i and year t , Digital Access is the level of accessibility to digital technologies in a country; AvgCG is average country governance, γ_t is the year fixed effects, and ε_{it} represents the error terms. All remaining control variables are described and explained in Table 6 in Appendix.

Findings

Hypothesis 1 examines the effect of digital access and the transparency index, along with control variables on MSV. Table 3 shows the results of the effects of digital access and country-level transparency on MSV. The p value of the Hausman test (fixed effects–random effects) $\text{Chi}^2(6)$ is 0.688. This statistic, aligned with the above-mentioned theoretical justification, indicates random effects regression is appropriate to test the hypotheses. Models 1 and 3 present the

Table 3 Baseline model: impact of digital access on MSV

	Dependent variable: MSV			
	Pooled OLS regression		Random effects regression	
	(1)	(2)	(3)	(4)
Digital access	−0.348*** (0.081)	−0.213** (0.083)	−0.515*** (0.077)	−0.523*** (0.083)
Transparency	−0.376*** (0.078)		−0.299*** (0.104)	
Avg. country governance		−1.526*** (0.248)		−1.068** (0.507)
Inflation	0.013 (0.053)	−0.027 (0.044)	−0.028 (0.021)	−0.028 (0.022)
Population growth	−0.376*** (0.077)	−0.319*** (0.084)	−0.457** (0.179)	−0.390** (0.181)
Inflow of foreign population	−0.028** (0.014)	−0.041*** (0.012)	−0.013 (0.038)	−0.018 (0.038)
GDP growth	−0.086** (0.042)	−0.069* (0.042)	−0.039 (0.024)	−0.042* (0.023)
Constant	2.688*** (0.518)	1.773*** (0.311)	2.471*** (0.734)	1.618** (0.704)
Observations	304	304	304	304
R^2	0.628	0.665	0.614	0.640
Year FE	Yes	Yes	No	No
Hausman test (Chi^2 – p value)			0.687	0.804

Table 3 reports results of the pooled OLS regression and random effects regression of digital access on MSV and transparency index, average country governance along with economic factors. The robust standard errors in parentheses are calculated and are Huber–White heteroscedasticity-consistent. The marks ***, **, and * represent the levels of significance 1, 5, and 10%, respectively. Table 6 in Appendix shows the detailed definition for the variables in the study

results of pooled OLS and random effects regressions. The coefficients of digital access and the transparency index are $\beta_1 = -0.348$, $p < 0.000$ and $\beta_2 = -0.376$, $p < 0.000$, respectively, in Model 1, whereas in Model 3 they are $\beta_1 = -0.515$, $p < 0.000$ and $\beta_2 = -0.299$, $p < 0.004$. The statistically significant negative impact on MSV is consistent in both the models. R^2 s are 0.628 and 0.614, respectively. These models show that digital access and the transparency index, when combined with the control variables, can explain 61–63% of the change in the dependent variable (MSV) (Elshandidy et al., 2015). Thus, these results support Hypothesis 1, indicating that higher levels of digital accessibility reduce vulnerability to modern slavery, and greater transparency is similarly linked to lower MSV (Rauscher & Willert, 2020).

To examine Hypothesis 2, the average country governance is included along with the digital access variable and country control factors (Eq. (2)). Table 3 shows the results of the effects of digital access and average country governance on the MSV. In Models 2 and 4, the results of pooled OLS and the random effects regressions are reported. The p value of the Hausman test (fixed effects–random effects) is 0.804. The insignificant results to the threshold $p < 0.05$ recommend that a random effects regression is appropriate. This also confirms that the differences across countries have an impact on the MSV. The coefficients of digital access and the average country governance are as follows in Model 2 ($\beta_1 = -0.213$, $p < 0.011$) and ($\beta_2 = -1.526$, $p < 0.000$), whereas the coefficient values are $\beta_1 = -0.523$ ($p < 0.000$) and $\beta_2 = -1.068$ ($p < 0.000$) in Model 4. The statistically significant negative coefficient value of MSV is consistent in both models. The R^2 s are 0.687 and 0.804, respectively. These models show that digital access and average country governance, along with the control variables, explain 64 to around 67% of variations in MSV (Mahmoudian et al., 2021). Thus, our Hypothesis 2 is supported.

These findings lend support to the predictions of information poverty theory. Because of better informational capabilities and greater access to digital technologies, people are more knowledgeable, less susceptible to manipulation, and less vulnerable. Thus, the theoretical framework supports the empirical findings of a decrease in MSV.

To confirm these results, a quantile regression is employed for the full sample. The quantile regression (Koenker & Bassett, 1978; Ortas et al., 2019) approximates quantiles of MSV and establishes a better explanation of the distribution of this dependent variable in the models. This type of regression is robust to leptokurtosis, heteroscedasticity, and skewness (Baur et al., 2012). In addition, the quantile regression addresses the relationship between different distribution points of the dependent variable and the independent variables, which is a major concern in OLS regression (Demir et al., 2022).

Table 4 shows that improvement in and development of digital access decreases vulnerability to modern slavery. The coefficients of digital access and transparency index are: Model 1 (Q10): $\beta_1 = -0.465$, $p < 0.000$ and $\beta_2 = -0.181$, $p < 0.113$; Model 2 (Q25): $\beta_1 = -0.475$, $p < 0.000$ and $\beta_2 = -0.141$, $p < 0.277$; Model 3 (Q50): $\beta_1 = -0.557$, $p < 0.000$ and $\beta_2 = -0.148$, $p < 0.056$; Model 4 (Q75): $\beta_1 = -0.507$, $p < 0.000$ and $\beta_2 = -0.352$, $p < 0.001$; Model 5 (Q90): $\beta_1 = -0.221$, $p < 0.151$ and $\beta_2 = -0.904$, $p < 0.000$, respectively. In particular, the signs of the regression coefficients for both digital access and transparency in Models 3 and 4 are consistent with Table 3. This indicates that an increase in digital access and transparency in the OECD countries is associated with a reduction in MSV (statistically significant coefficients are seen for both DA and transparency in quantiles 50 and 75). On the other hand, Models 6–10 have statistically significant and negative coefficients at all quantiles, indicating that the MSV-reducing effects of digital access as well as country governance increase in most of the upper part of the MSV distribution, showing that heterogeneous effects may be overlooked by traditional regression models (Powell, 2022). The equality test results for both transparency and average country governance reject the null hypothesis that all regression coefficients are equal.

Robustness Check

To address undetected endogeneity due to reverse causality issues that may arise because of endogenous digital access variables, two-stage least squares (2SLS) regression is applied. The *GDP per person employed* (or per hour worked) is used as an instrument for DA. Prior studies indicate that the GDP per person employed can be used as the level of labour productivity (Evangelista et al., 2014; Oulton & Sebastia-Barriel, 2017). Moreover, labour productivity in the ICT sector significantly surpasses that in other sectors, particularly in developed nations such as those in the OECD (OECD, 2014). Enhanced information accessibility empowers individuals with greater capabilities (Kolstad & Wiig, 2009), enabling them to achieve higher productivity levels (Dahlman et al., 2016). Thus, GDP per person employed is utilised as an instrument for DA.

Data for the instrumental variable is collected from the World Bank database. The updated sample is comprised of 304 country-year observations when the GDP per person employed variable is used. In the first stage, the R-squared and F-statistics coefficients are reported in Models 1 and 3 in Table 5. The instrument is both valid and statistically significant, showing goodness of fit of the regressions in the first stage. The instrument passes the diagnostic tests such as the Anderson LM test (under-identification) and Cragg-Donald Wald F -statistics (weak identification). In these models, the instrument is regressed on the endogenous variable (DA),

Table 4 Quantile regression: impact of digital access on MSV at different quantiles

	Dependent variable: MSV									
	Q10	Q25	Q50	Q75	Q90	Q10	Q25	Q50	Q75	Q90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Digital access	-0.465*** (0.122)	-0.475*** (0.128)	-0.557*** (0.085)	-0.507*** (0.093)	-0.221 (0.165)	-0.223*** (0.081)	-0.353*** (0.101)	-0.527*** (0.095)	-0.418*** (0.107)	-0.300** (0.130)
Transparency	-0.181 (0.115)	-0.141 (0.136)	-0.148** (0.071)	-0.352*** (0.092)	-0.904*** (0.157)					
Avg. Country Gov						-1.047*** (0.205)	-0.752*** (0.279)	-0.595* (0.356)	-1.504*** (0.381)	-2.402*** (0.258)
Inflation	-0.035 (0.037)	-0.044 (0.048)	-0.038 (0.069)	0.020 (0.088)	0.014 (0.086)	-0.051* (0.031)	-0.084** (0.043)	-0.039 (0.068)	0.015 (0.063)	-0.087 (0.055)
Population Growth	-0.164* (0.090)	-0.381*** (0.074)	-0.424*** (0.136)	-0.336** (0.131)	-0.041 (0.282)	-0.155** (0.073)	-0.335*** (0.081)	-0.396*** (0.141)	-0.237* (0.130)	-0.117 (0.233)
Inflow of Foreign Population	0.003 (0.013)	-0.029*** (0.010)	-0.047*** (0.011)	-0.063** (0.028)	-0.114* (0.059)	-0.017* (0.010)	-0.028*** (0.010)	-0.056*** (0.012)	-0.066*** (0.018)	-0.103*** (0.038)
GDP Growth	-0.047 (0.057)	-0.069 (0.052)	-0.074 (0.054)	-0.069 (0.051)	-0.046 (0.070)	-0.077** (0.038)	-0.072 (0.052)	-0.073 (0.054)	-0.072 (0.050)	-0.025 (0.069)
Constant	0.488 (0.733)	0.631 (0.887)	1.431*** (0.505)	3.145*** (0.654)	7.499*** (1.003)	0.380* (0.227)	0.541 (0.329)	1.091** (0.430)	2.414*** (0.542)	4.410*** (0.414)
Observations	304	304	304	304	304	304	304	304	304	304
Equality test					Transparency 6.36 ($p=0.000$)					Avg. Country Gov 7.83 ($p=0.000$)
Pseudo R^2	0.396	0.431	0.448	0.451	0.442	0.435	0.447	0.454	0.478	0.493
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table offers results of quantile regression (Q10, Q25, Q50, Q75, and Q90) of digital access, average country governance and transparency index, along with macroeconomic factors. The standard errors in the parentheses are calculated by 1000 bootstrap samples. The equality test used is an F test, where the null hypothesis states that the estimated slope coefficients for transparency and average country governance do not differ statistically across the quantile estimates. The marks ***, **, and * represent the levels of significance 1, 5, and 10% respectively. Table 6 in Appendix shows the detailed definition for the variables in the study

Table 5 Robustness test—impact of digital access on MSV

Dependent variable: MSV	(1)	(2)	(3)	(4)	(5)	(6)
	Transparency		Country governance		PCA: country gov. and transparency	
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
Digital access		−1.470*** (0.475)		−1.353*** (0.448)		−1.364*** (0.450)
Transparency	0.611*** (0.028)	−0.273** (0.091)				
Avg. country gov			1.814*** (0.095)	−1.524*** (0.471)		
Country gov and transparency (PCA)					0.429*** (0.022)	−0.406*** (0.112)
GDP per person employed (instrument)	0.919*** (0.156)		0.726*** (0.160)		0.752*** (0.157)	
Inflation	−0.073*** (0.027)	−0.023 (0.019)	−0.031 (0.031)	−0.021 (0.019)	−0.035 (0.031)	−0.023 (0.019)
Population growth	−0.377*** (0.090)	−0.424*** (0.090)	−0.307*** (0.079)	−0.339*** (0.092)	−0.323*** (0.081)	−0.350*** (0.090)
Inflow of foreign population	0.016* (0.009)	0.046 (0.039)	0.033*** (0.010)	0.039 (0.039)	0.029*** (0.010)	0.041 (0.039)
GDP growth	−0.042** (0.020)	−0.018 −0.023	−0.050*** (0.018)	−0.020 (0.014)	−0.049*** (0.018)	−0.018 (0.014)
Constant	−4.75*** (0.212)	—	−2.523*** (0.171)	—	−0.454** (0.175)	—
Observations	304	304	304	304	304	304
R ² (1st stage)	0.775	—	0.766	—	0.771	—
F-statistics (1st stage)	10.700		10.740		10.690	
Anderson conon. corr LM (Chi2)	10.833***		10.870***		10.820***	
Cragg–Donald Wald F-Statistics	10.702		10.740		10.689	

This table presents the 2SLS regression with the panel data. GDP per person employed is used as an instrument for digital access which is an endogenous variable. The *F*-statistics and R-squared in the first stage show the validity of instruments. Models 5 and 6 include a combined variable of country governance and Transparency calculated by principal component analysis. The standard errors in the parentheses are calculated by adjusting the heteroscedasticity. The marks ***, **, and * represent the levels of significance 1, 5, and 10%, respectively

including the control variables and fitted value is obtained (see Models 1 and 3). The fitted value of DA is then used in the second stage, and the coefficients are reported in Models 2 and 4 in Table 5. The results show that the coefficients for transparency and DA are negative and statistically significant in Model 2. Similarly, Model 4 reveals a negative and statistically significant coefficient for DA and average country governance. Thus, the findings continue to confirm the main results and support the hypotheses.

As previously indicated, the PCA is acknowledged to be a robust statistical technique to combine two overlapping factors—decrease noise (Gull et al., 2018; Paolella et al., 2021) and decrease the loss of information to a minimal level (Capelle-Blancard et al., 2019). Hence, the PCA is used to calculate a principal component score based on the country governance factors and the transparency index

(KMO = 0.926; Bartlett's test of sphericity is significant ($\chi^2(21) = 4280.806$, $p < 0.001$). These tests confirm the adequacy of the construct. The overall country governance and transparency variable from PCA is used in the 2SLS model. In Model 6 of Table 5, the coefficient indicates that DA and the new variable (country governance and transparency) are negatively related and strongly statistically significant. These findings are consistent with the previous estimates presented in Tables 3 and 4.

Results support the view that enhanced digital access contributes to greater protection of human dignity by reducing information poverty and enabling at-risk populations to access resources, report abuse, and improve their socio-economic conditions. These findings align with existing literature on the significance of digital access in mitigating modern slavery risks (Jiang et al., 2023). In addition, this

study also highlights that digital access can reduce modern slavery vulnerability, where governance structures are transparent and accountable. Thus, the findings contribute to the governance literature within the context of modern slavery (Albitar et al., 2025) whilst simultaneously emphasising the importance of digital access in research exploring the intersection between governance and modern slavery vulnerability.

The originality of this paper is strengthened by its application of information poverty theory to examine empirically the relationship between digital access and vulnerability to modern slavery. Digital access is widely recognised as being a major determinant of whether people can participate in the information society, there being a strong correlation with information poverty (Acheampong et al., 2025; Al-Zaman, 2023). Digital access is a necessary but not sufficient condition for overcoming information poverty. Inequalities in internet access, device availability, digital skills, and affordability shape who can obtain information and who cannot. Nevertheless, other factors may be at play in relation to information poverty, such as social justice, location in rural areas, information rights, access to information, social exclusion, information management, information processing, socio-economic factors, poverty, and health services, which are all interconnected with information poverty (Al-Zaman, 2023; Ghosh & Barui, 2025; Zeng et al., 2025).

Information poverty is exacerbated by globalisation, as the increased movement of vulnerable individuals across borders makes it more difficult to track exploitation and provide protection (Flynn & Walker, 2021). In addition, whilst digital access can empower at-risk populations, it also introduces new risks by enabling exploiters to use technology for coercion and control, further complicating efforts to mitigate modern slavery vulnerabilities. Thus, this theoretical framing helps bridge individual vulnerabilities with enablers of modern slavery reduction, providing a more holistic conceptual model.

The findings suggest that whilst digital inclusion contributes to reducing modern slavery vulnerabilities, its effects are not uniform across the distribution, as presented using quantile regression. This indicates that digital access alone is unlikely to be sufficient. Instead, progress is more likely when accompanied by improvements in country-level governance that strengthen institutional transparency and regulatory accountability. For businesses, particularly those managing global supply chains, the study provides empirical justification for investing in digital traceability tools and stakeholder engagement platforms, but their effectiveness is contingent on robust governance structures that can support and enforce such initiatives.

By combining theory-driven hypotheses with a robust cross-national panel dataset, this research advances the understanding of how digital transformation intersects with

human rights protection, offering clear directions for future research and practical action.

Discussion

Implications of Results

This study has several unique contributions to the modern slavery literature. First, the study offers the first empirical evidence on how digital access plays a vital role in the reduction of modern slavery vulnerability at the country level. Second, it introduces information poverty theory in a systematic and measurable way and expands its application beyond traditional contexts. Third, by incorporating digital access with governance and transparency factors, the study provides a multi-level structure that shapes and affects vulnerability. Finally, a decade-long panel dataset across 31 OECD countries that contributes a robust analytical improvement is used, enabling insights that the existing literature lacks. Altogether, the contributions identify the research paper as providing an evidence-based approach for the reduction of modern slavery vulnerability.

Research into modern slavery, its causes and how to reduce it, is in its infancy (e.g. Caruana et al., 2021). This study advances and demystifies understanding of the ethics of access to digital communication technology and its impact on the reduction of MSV. This is the first study analysing country-level data in an empirical way and using various types of regressions of the relationship. The relevance of information poverty theory is modelled, confirmed and extended, with results suggesting that in the future theoretical framing needs to consider vulnerability to modern slavery.

Prior literature is concerned with how people are drawn into, extracted from and kept out of returning to modern slavery over time. Whilst the number of published cases about victims is increasing, there is little empirical evidence available. Obtaining systematic foundational evidence is a key motivation behind this research. Although access to digital communication technologies has been suggested as a first-order condition for reducing modern slavery vulnerability, this is not well established in the literature, with authors such as Asokan et al. (2022), Malpass et al. (2022), and Walk Free Foundation (2018) drawing thinking towards confirmation that such a relationship exists. Results from testing Hypothesis 1 confirm the negative association between digital access and reduction of MSV in high transparency countries, indicating that an increase in digital access will reduce vulnerability to modern slavery.

Confirmation of the statistical significance of the association between variables posited in Hypothesis 1 says nothing about the ending of modern slavery, which is the goal of the

United Nations, to be achieved by 2030. However, it does add support to the notion that, across the countries included over the 10-year period of data sampled, the extent of digital access has a direct effect on reducing MSV. The implication is that processes to encourage greater digital access are to be encouraged through removal of digital access roadblocks leading to information poverty reduction.

The results in relation to Hypothesis 1 encourage second-order questions to be asked about possible key processes operating behind this relationship. Whilst being mindful of MacKinnon and Fairchild's (2009) warning that Baron and Kenny's (1986) causal-steps approach can be a fallible statistical test that is subject to error, the result in relation to Hypothesis 2 lends support to further testing for other factors affecting MSV. Confirmation of the negative relationship between digital access and MSV in highly governed countries posited in Hypothesis 2 goes against the view of Kenny (2002). This result could reflect progress in cost reduction of digital communications, the rapid distribution of smart phones and movement away from analogue systems in the last two decades.

The empirical evidence presented supports and extends the view of Malpass et al. (2022). It leads to the conclusion that, to reduce vulnerability caused by information poverty, interested parties, such as governments, businesses and non-government organisations, could work together on digital access to improve resources for support staff to assist digital skills development of potential and actual victims, as well as for victims that have survived. This could be achieved by encouraging actions to promote development of internet infrastructure and availability of and access to digital equipment by potential, actual, and past workers.

Future Research Opportunities

In both theoretical and empirical terms, this research confirms an interrelationship between digital access and modern slavery vulnerability, which suggests that it should be considered in the future academic research and in policy making and business decision-making, to reduce modern slavery vulnerability.

Implications for Theory

With the predictive ability of information poverty theory demonstrated in relation to digital access, future research could usefully extend the application to consider the problem of modern slavery vulnerability in specific settings, in particular in countries where modern slavery is prevalent, and in specific industries and businesses. With the current absence of large databases about modern slavery vulnerability, case studies would provide a useful addition by examining the most effective ways to harness digital access for

reducing vulnerability in particular settings. Over time these could be built up such that further generalisations about reducing modern slavery vulnerability could be developed in a similar way to the approach of Mintzberg (1971), who used a build-up of case studies over time to identify different management roles in business. Case studies at the firm level could also reveal the practical ways in which digital access can reduce modern slavery in countries and could reduce it in business.

In addition, the current results raise the question of future research into predicting the relative efficacy of improving digital access to reduce modern slavery vulnerability in comparison with disclosure-based legislation (Birkey et al., 2018), and the relationship between these. Clear evidence is presented that vulnerability to modern slavery decreases as internet users, fixed and mobile phones users, broadband subscribers, and digital literacy increase. Nevertheless, this research could be extended to examine possible mediating and moderating roles of transparency and governance in relation to digital access and modern slavery vulnerability.

In line with potential research into mediating and moderating effects, an implication of the results of the current research is that it would be useful to examine linkages between vulnerability and digital access by examining different types of risk, or as a minimum the main categories of modern slavery, such as forced labour, extreme forms of child labour and bonded labour.

Future theory could look for improved predictors of digital access and vulnerability when data are available, such as links with internet usage, the level of literacy, and price effects related to free wi-fi availability in different countries.

Finally, the countries being studied could be extended to include developing countries, as indicated by Szablewska and Kubacki (2023). Supply chains and modern slavery are most prevalent in Africa, followed by Asia and the Pacific region, and the emphasis on legislated transparency is largely in developed countries (Transparency International, 2024). Hence, gaining knowledge of potential links between digital access tools and levels of transparency as predictors of modern slavery vulnerability in developing countries holds promise for better understanding about ending modern slavery.

Implications for Policymakers

Government policy makers are committed to the aspirational SDGs' aim towards ending modern slavery. Results of this research predict that one way in which governments can contribute to the reduction of modern slavery is to reduce the vulnerability of people. In this respect, the suggestions of information poverty theory are borne out. Access to digital infrastructure, affordability and knowledge are confirmed to be associated with vulnerability, as well as with a country's

levels of transparency (RQ1) and governance (RQ2). Future research into levels of literacy in different countries on digital access and digital understanding, especially in non-OECD countries, would add to further understanding of the use of information poverty theory as a foundation for predicting expected reductions in modern slavery vulnerability.

In general, the results indicate that policy makers can look for and encourage implementation of practices which reduce vulnerability of modern slavery in any country. Policy makers can be confident that, where there is no specific disclosure legislation, on average businesses will be contributing towards movement away from modern slavery. Policymakers will need to encourage further research into the phases of modern slavery practices/business models where their tools will be most effective. For example, this could be through preventative, detective or reactive means as outlined by Bodendorf et al. (2023). Thus, the ethical implications of the findings are significant, highlighting the moral responsibility of policymakers and businesses to leverage digital access as a tool for empowerment and protection against exploitation and consider how best this can be achieved. However, as data are not currently available for such testing, case studies would be illuminating.

Implications for Business Managers

Responsibility for reducing MSV in business operations and supply chains ultimately rests with top management (e.g. Doorey, 2011). Nevertheless, results from the current research, confirming that vulnerability of potential and actual employees to modern slavery needs to be reduced, raise the issue of how managers might make progress with the issue. Given the proxies used for this study, one way forward is for managers to look towards introducing innovations in digital communications, through investment in research and development and, more controversially, promotion of school education through tailored philanthropy perhaps involving non-government organisations. Competitive power relations, such as those exposed in political decisions to ban Huawei from 5G rollout (Stokel-Walker, 2019), bring the relationship between government and business institutions to the fore in the future research, as concern has been over the impact on trade and security rather than on labour conditions (Gutierrez-Huerter, 2023).

Results also confirm that managers in the agriculture, services, and education sectors considered, can be singled out for close attention and support in relation to reducing vulnerability as well as modern slavery per se. Further research is needed into how different types of managers (e.g. procurement, marketing, and human resources) impact vulnerability of workers; yet, without suitable databases such empirical research cannot progress and, again, case studies might be needed to provide early evidence of such relationships.

Finally, it is hoped that this research stimulates further investigation into how stated versus perceived vulnerability to modern slavery and their fit affect organisational targets for reducing modern slavery.

Limitations of the Study

Readers need to be mindful of possible extensions of the research to the information poverty theoretical perspective to the individual, rather than the business level adopted here. In particular, individual psychology might affect the take up of digital information and this and its effect on modern slavery vulnerability remains for future investigation (Zhang & Yang, 2023).

In terms of the empirics, this novel research is limited by the data sets currently available. There will be a need for improved proxies to be developed as larger, longer and more varied databases emerge.

The country-level data are limited because geographical risk and regional legislation are likely to affect access to digital communication technology and, consequently, could influence MSV. Moreover, it is possible for there to be a common method bias in the form of a systematic error variance when estimating the relation between the constructs with the same method. Mitigation of this limitation was partially undertaken in the robustness tests, but reverse-coded items for constructs could be helpful in the future studies using yet to be acquired survey data.

Conclusion

The paper concludes that, given the predictive results of this empirical investigation, expanding access to the means for digital access by states and businesses is ethically significant because it can be used to build informational environments that help reduce modern slavery exploitation.

Modern slavery is a complicated and pervasive problem that continues to plague society. Although modern slavery is often spoken about in terms of statistics and numbers, each represents a vulnerable person. Victims are children, mothers, and fathers. Society can and must do better and this research goes somewhat towards explaining how vulnerability can and should be reduced through better digital access for people who need to avoid, or who are trapped in, modern slavery. In this way, predictable ethical failure arising from information poverty can be avoided through improved business decisions and government policymaking.

Appendix

See Table 6.

Table 6 Variables' definition and sources

Variable name	Variable description	Variable source
Modern slavery vulnerability	Score of Principal Component Analysis (PCA) for employment in agriculture and services, total unemployment, total youth outside educational system, and total youth unemployed	WB
Digital access	Score of PCA for levels of mobile, telephone, and broadband subscriptions; internet users; and school enrolment (primary, secondary, and tertiary) in a country each year	WB
Country-level-related data		
Transparency index	Value showing the level of country transparency	www.transparency.org
Gross domestic product growth	Country's annual GDP growth (in %)	WB
Inflation	Level of inflation in a country (in %)	WB
Population growth	Level of annual population growth in a country (in %)	WB
Inflow of foreign population	Number of people flowing into a country (in '000)	OECD
Governance indicators		
Political stability/no violence	Depicts level of political instability and political-driven violence and terrorism	WGI
Voice and accountability	Measures participation of citizens in government selection, freedom of association, free media, and expression	WGI
Government effectiveness	Measures civil and public services quality, political independence, formulation and implementation of policies, and government's credibility	WGI
Regulatory quality	Measures governmental ability to develop and stimulate the private sector through regulations and policies formulation and implementation	WGI
Rule of law	Measures degree to which citizens are confident in society's rules and accept them. Also measures quality of property rights, possibility of violence and crime, and contract enforcement	WGI
Control of corruption	Measures level of power of public for private gain and interest in form of corruption	WGI
Average country governance (Lodh et al., 2023)	The average of 6 factors of governance: VoA, GE, RegQ, RoL, CoC, and PS	

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Data Availability Data are available from the authors upon request.

Declarations

Conflict of interest The author have no conflict of interest to declare.

Ethical Approval Ensuring the integrity of our research through strict adherence to ethical standards is of utmost importance. We confirm that there are no conflicts of interest, thereby safeguarding professional judgement from personal or financial influences. Our research does not involve human participants or animals. We also prioritise informed consent, making sure that all co-authors are fully aware of the nature of the research. Ultimately, compliance with ethical standards goes beyond merely following rules; it is about committing to doing what is right and just in all circumstances.

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