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Trong-Anh Trinh

(Monash University)

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Trong-Anh Trinh*
Monash University

Abstract

Informal employment remains pervasive in many developing economies, limiting worker protection and government revenue. This study examines whether expanding mobile internet access reduces workers' reliance on informal jobs in Vietnam. Linking four waves of the Vietnam Household Living Standards Survey (2014–2020) to district-level 3G network coverage, we instrument coverage using regional lightning-strike intensity to address endogeneity in infrastructure rollout. Our main results show that a one-standard-deviation increase in mobile internet availability lowers the probability of informal employment by 25%. The effect is particularly large for women and younger workers, groups that face greater information and mobility constraints in formal labour markets. Our mechanism analysis using firm-level data suggests that internet expansion increases the likelihood of firm formalisation, thereby creating additional opportunities for formal employment. These findings indicate that policies expanding mobile broadband coverage, especially in underserved areas, can support labour-market formalisation and economic development.

Keywords: Mobile internet, informal employment, Vietnam, gender disparities
JEL Classification: J21, J23, O33

* Centre for Health Economics, Monash Business School, Monash University (email: Trong-Anh.Trinh@monash.edu). I am grateful to the funding from the Economic Research Institute for ASEAN and East Asia.

1. Introduction

In developing countries, informal employment represents a significant proportion of the labour market. Recent estimates from the International Labour Office show that in low-income economies, around 90% of employment is informal, even when excluding agriculture, the most common sector in these economies (Bonnet et al., 2019). The persistence of informal employment is often attributed to limited regulatory enforcement, insufficient job opportunities in the formal sector, and lower labour costs for firms (Kucera and Xenogiani, 2009). However, workers in the informal sector typically lack job security, social protection, and access to financial services, exposing them to greater economic vulnerability and persistent poverty (Amuedo-Dorantes, 2004; Camacho et al., 2014; Arias et al., 2018). Policies that facilitate a transition to formal employment are essential to improving workers' livelihoods, enhancing productivity, and broadening the tax base.

This paper investigates the role of internet access in reducing workers' reliance on informal employment. Internet access has become a key driver of development in many low-income settings, contributing to improvements in education, health outcomes, and business opportunities (Hjort and Poulsen, 2019; Lakdawala et al., 2023; Kunz et al., 2024). Despite these benefits, internet penetration remains low in many developing contexts, with less than 35% of the population having access (Rodriguez, 2021). Conceptually, internet access can promote formalisation by connecting workers to job information, facilitating skill acquisition through online learning, and enabling access to formal job search platforms. These mechanisms can reduce search frictions, increase awareness of labour rights, and ultimately facilitate entry into the formal labour market. In addition, internet expansion may encourage firm formalisation by lowering compliance costs, easing access to digital financial services, and enabling participation in e-commerce, thereby increasing the supply of formal jobs. Given these potential benefits, it is reasonable to expect that greater internet access decreases the likelihood that workers engage in informal employment.

Even when internet access brings overall benefits to employment outcomes, these gains may not be evenly distributed across all population groups. One important dimension of heterogeneity is gender. Female workers disproportionately dominate the informal labour force in many developing economies, often due to limited access to formal job opportunities, lower skill levels, and societal constraints (Radchenko, 2017; Klasen et al., 2021). Because of these conditions, internet-driven improvements can be especially meaningful for women, helping them overcome entry barriers into the formal sector and thereby narrowing gender gaps in employment.

Another dimension of interest is how the effects of internet access on informal employment vary across age groups. Of particular interest are young individuals who have recently completed school or university, as they represent a critical demographic in the labour market. This group often faces unique challenges in securing formal employment, such as limited work experience, lack of professional networks, and higher levels of job market uncertainty. Internet access can play a transformative role for these individuals by providing platforms for online job searches, enabling participation in virtual internships, and facilitating skill-building through digital resources (Kuhn and Mansour, 2014). By doing so, this study explores the mechanisms through which internet access influences the formalisation of employment among young workers.

To answer these questions, we focus on Vietnam, a particularly relevant context given the prevalence of informal employment. Informal employment has long been a key feature of the Vietnamese labour market, accounting for nearly 80% of total employment (McCaig and Pavcnik, 2015). Women make up a substantial share of this workforce, reflecting the gendered nature of informality (Rand and Torm, 2012). Recognising these challenges, the Vietnamese government has implemented initiatives to encourage formalisation, including reforms in labour regulations and social security programs (Buckley, 2023). Additionally, Vietnam has experienced rapid growth in internet penetration in recent years, with approximately 72% of the population now having access, although significant disparities remain between urban and rural areas (Liang and Li, 2023). This context makes Vietnam an ideal case study for understanding how variation in mobile internet access influences workers' propensity to engage in informal employment.

Relying on simple Ordinary Least Squares (OLS) estimates to examine the association between internet access and employment formalisation raises concerns about endogeneity. Areas with more robust economic prospects, better infrastructure, or stronger labour market conditions may attract investments in internet coverage, making reverse causality a possibility. Moreover, unobserved local factors, such as policy initiatives or community networks, could simultaneously influence both internet expansion and labour market outcomes, leading to omitted variable bias. To address these issues, this paper employs an instrumental variable (IV) strategy, using lightning strikes as an exogenous determinant of internet coverage (Manacorda and Tesei, 2020; Guriev et al., 2021; Do et al., 2023; Kunz et al., 2024). The underlying logic is that regions prone to more lightning strikes face higher maintenance costs for telecommunications infrastructure, deterring internet providers and thus generating plausibly

exogenous variation in coverage. By leveraging this natural source of variation, we can more reliably identify the causal impact of internet access on informal employment.

Employing a two-stage least squares specification with individual-level controls and province-year fixed effects, we find that mobile internet expansion significantly reduces the likelihood of informal employment. Specifically, a one-standard-deviation increase in internet coverage reduces the probability of informal employment by approximately 14.3%, equivalent to about 25% of the mean informality rate. Heterogeneity analyses reveal significant gender differences, with the effects primarily driven by women. Similarly, the impact is largely concentrated among younger cohorts, suggesting that these groups may be more adept at leveraging digital resources for skill acquisition, job searches, and other pathways toward formal employment. Using firm-level data, we also find suggestive evidence that a one-standard-deviation increase in internet coverage raises the likelihood of firm formalisation by about 17.2%, consistent with the mechanism that internet expansion can increase the supply of formal jobs.

This research contributes to the broad literature on the factors determining the transition from informal to formal employment. Existing studies have explored various dimensions, including trade openness, economic shocks, labour regulations, and firm productivity (e.g., Goldberg and Pavcnik, 2003; Fukase, 2013; McCaig and Pavcnik, 2015; Arias et al., 2018; Erten et al., 2019). Generally, findings suggest that factors such as regulatory quality, access to credit, and worker skills play a pivotal role in facilitating transitions. Other studies emphasise the importance of reducing entry barriers, increasing job stability, and expanding social security coverage to incentivize formalisation (Loayza and Rigolini, 2011; Camacho et al., 2014; Rothenberg et al., 2016; Colombo et al., 2019). At the same time, a growing body of research has examined the role of technology in this transition and highlights the risk posed by factors such as robotic advances in reducing formal jobs, potentially leading to a shift back to the informal sector as a buffer (Brambilla et al., 2023; Graetz and Michaels, 2018; Faber, 2020). This paper departs from these studies by exploring the role of internet access, particularly mobile internet, in facilitating the transition from informal to formal employment by enhancing access to labour market information, improving workers' skill sets, and providing platforms for formal job searches.

This paper also contributes to the literature examining the impacts of internet availability on labour market outcomes. Previous studies have established significant associations between internet access and improvements in productivity, employment opportunities, and labour market participation in various settings (Akerman et al., 2015; Barrero et al., 2021; Zuo, 2021).

For example, Hjort and Poulsen (2019) report substantial productivity gains following the introduction of wired broadband internet in Africa, illustrated by 6.9% increase in the probability that an individual is employed when fast Internet arrives. Several studies underscore the heterogeneity in these benefits, emphasising greater positive impacts for female workers or individuals residing in rural areas (Dutz et al., 2017; Chun and Tang, 2018; Bahia et al., 2024).

Close to our paper is the study by Chiplunkar and Goldberg (2022), who examine the employment effects of 3G mobile internet across multiple developing countries. Using lightning strikes as an instrumental variable, they find significant positive impacts on both male and female labour force participation rates, although they highlight distinct gender-specific employment patterns: men tend to shift from unpaid agricultural roles to small entrepreneurial activities, while women increasingly take unpaid positions or operate small businesses. Our study departs from this and previous work by focusing on informal employment, a crucial dimension given that formal jobs typically offer greater security and access to benefits such as social insurance and legal protections. Understanding how internet availability can influence informality is therefore vital for designing policies that foster inclusive economic growth and more equitable labour markets.

By doing so, we are also closely related to Kusumawardhani et al. (2023), who focus specifically on female labour market outcomes in Indonesia. Using the proportion of villages in which the internet is available, they find modest positive impacts of internet access on female labour force participation and full-time employment among younger and less-educated women. However, they also report negative effects on job formality, suggesting that women living in areas with higher internet availability are less likely to work in formal jobs. These divergent findings highlight the importance of contextual factors—such as economic structure, policy environment, and sociocultural norms—that can mediate the impact of internet access on labour market outcomes. By concentrating on Vietnam, where rapid internet expansion coincides with a large informal sector and persistent gender disparities, our paper sheds new light on how these contextual differences may shape the relationship between internet access and informal employment.

The rest of the paper is organised as follows. Section 2 provides an overview of the informal employment sector and internet services in Vietnam and outlines a conceptual framework illustrating how internet access may facilitate the transition to formal employment. Section 3 describes the data sources and key variables, while Section 4 details the econometric methodology. Section 5 presents and discusses the empirical results. Finally, Section 6 concludes.

2. Background

2.1. Informal employment in Vietnam

Vietnam's economic landscape has been profoundly shaped by the "Đổi Mới" reforms launched in the late 1980s, which transitioned the country toward a more market-oriented system. These reforms have contributed to robust GDP growth, declining poverty rates, and high labour force participation, with unemployment rates remaining relatively low compared to other developing economies (O'Higgins and Viegelahn, 2021). Nonetheless, informal employment continues to be widespread in Vietnam's labour market. According to International Labour Organization's guidelines, an informal job can be understood as one lacking legal or social protections—most notably, no official labour contract or social insurance coverage—thus placing workers outside the scope of formal labour regulations.

Recent estimates suggest that informal employment in Vietnam accounts for roughly 68.5% of total employment when agricultural activities are included (GSO, 2021). This figure translates to around 33.6 million individuals whose livelihoods depend on unregistered enterprises, casual work arrangements, and subsistence agriculture. Although urban industrial areas such as the Southeast region show lower rates of informality (below 50%), the Central Highlands and parts of the Mekong Delta record figures exceeding 80%, indicating persistent regional disparities. Moreover, women outnumber men among the informally employed, and they tend to cluster in lower-wage, low-skill segments of both the agricultural and service sectors.

A heavy reliance on informal jobs poses numerous socioeconomic risks. Workers in informal employment typically lack entitlements to paid leave, severance benefits, or employer-provided social insurance, making them highly vulnerable to income shocks and economic downturns. Surveys show that over 90% of informal workers do not participate in any form of social insurance, and nearly half earn below the regional minimum wage (GSO, 2021). These conditions contribute to precarious livelihoods, minimal job security, and limited upward mobility. From a macroeconomic perspective, large-scale informality can reduce the state's tax base, inhibit productivity growth (as many informal enterprises remain small and undercapitalized), and exacerbate inequality.

Recognising these vulnerabilities, the Vietnamese government has introduced policies and programs aimed at fostering a gradual transition from the informal to the formal sector. Over the past decade, amendments to the Labour Code have tightened requirements for written contracts, while social insurance reforms have made it easier for smaller enterprises and

household businesses to register. Additionally, targeted schemes to extend social protection, such as voluntary social insurance, seek to improve the coverage among groups historically absent from contributory programs. Although challenges remain, these efforts signal a growing policy commitment to reducing informality and ensuring that broader segments of Vietnam's workforce share in the benefits of the country's strong economic performance.

2.2. Internet development and digital expansion in Vietnam

Since the "Đổi Mới" reform, Vietnam has initiated policies aimed for major investments in information and communication technologies to facilitate expanding trade and attracting foreign investment. Public internet services officially launched in Vietnam in late 1997, a milestone that became possible after the government introduced new regulations to allow internet connectivity (Lam et al., 2004). In the early stages, much of the infrastructure, especially in urban areas, was operated by state-owned agencies, and prices were relatively high for end users. Despite these constraints, the internet user base steadily expanded, albeit from a modest starting point. By the early 2000s, key urban centres like Hanoi and Ho Chi Minh City witnessed a surge in internet cafés, as well as the first wave of domestic websites catering to news, education, and limited e-commerce services. However, most rural and mountainous regions remained substantially under-connected, reflecting both economic and geographic barriers to early-stage infrastructure rollouts.

From the 2010s onward, Vietnam entered on a significant phase of broadband expansion, facilitated by declining service costs, strengthened government policy, and substantial growth in mobile internet usage (Pham, 2023). The Ministry of Information and Communications, in partnership with major telecommunications providers, coordinated the widespread deployment of 3G and 4G networks, resulting in a rapid increase in smartphone penetration across both urban and rural areas. According to Pham (2021), rural broadband coverage, initially lagging behind urban centres, improved considerably through a combination of public subsidies and operator-led infrastructure investments, contributing to a narrowing of the digital divide. By the late 2010s, smartphone adoption rates surpassed 70%, with expanded internet access influencing social behaviours, business operations, and labour market opportunities. Although regional disparities in signal quality and digital literacy remain, Vietnam's experience illustrates the effectiveness of targeted policy interventions and market-driven incentives in accelerating nationwide digital transformation.

2.3. Theoretical framework

Theoretical models of the informal sector often distinguish between two primary views: (1) the segmentation hypothesis, which suggests that workers are involuntarily pushed into informal employment due to entry barriers into the formal sector, and (2) the competitive or dual labour market theory, which views informality as a voluntary choice made by workers seeking higher utility or returns that they might not achieve in formal employment (Loayza and Rigolini, 2011; Gunther and Launov, 2012). In the segmentation view, entry barriers, such as high regulatory costs, limited access to credit, and insufficient formal job opportunities, restrict workers from entering the formal sector, forcing them into informal jobs as a strategy of last resort. On the other hand, in the competitive framework, the informal sector may offer certain non-wage benefits (e.g., flexible hours, autonomy) that attract workers, making it a more desirable option for some, particularly those with low skill levels or limited mobility.

Building on these theories, internet access, particularly mobile internet, can reduce the segmentation of labour markets and incentivise workers to transition from informal to formal employment in several ways. First, internet access reduces informational asymmetries by providing workers with better access to information on available formal job opportunities, thereby lowering search costs and connecting them more efficiently with potential employers. Second, digital access facilitates skills acquisition through online learning platforms and vocational training programs, enabling workers to acquire certifications and credentials valued by formal sector employers. Third, internet access promotes financial inclusion by connecting workers to digital financial services, making it easier for informal entrepreneurs to formalise their businesses or access credit. By doing so, these firms may also expand the supply of formal jobs, reinforcing the transition from informality at the worker level. Finally, mobile internet can enhance compliance and awareness of labour regulations, allowing workers to understand their rights, thereby reducing the perceived risk and cost of formalisation.

3. Data

3.1. Household data

This paper uses data from multiple rounds of the Vietnam Household Living Standards Survey (VHLSS), a nationally representative, biennial survey conducted by the General Statistics Office (GSO) of Vietnam. The VHLSS is among the most comprehensive datasets available for studying household and labour market outcomes in Vietnam and has been widely used in empirical research on employment, informality, and welfare (e.g., Nguyen et al., 2013; McCaig and Pavcnik, 2015; 2018; Vu and Glewwe, 2022; Vu et al., 2022). The survey collects rich

information at the individual and household levels, including demographics, education, employment, income, and living conditions. A key strength of the VHLSS is its consistent coverage of both formal and informal labour market activities across multiple waves. This makes it particularly well suited for examining informality and the structural composition of employment in Vietnam.

In this study, we primarily use repeated cross-sectional data from the VHLSS conducted between 2014 and 2020. Each round covers approximately 9,000 households and over 36,000 individuals, drawn from all provinces and from both urban and rural regions of Vietnam. We restrict the sample to working-age individuals between 18 and 54 to minimise heterogeneity arising from schooling or retirement decisions. This age group has largely completed high school education and is not yet eligible for official retirement, making them more likely to be active participants in the labour force. To identify working individuals, we use the survey question asking whether a person reported having a job in the past 12 months.

To define informal employment, we follow the worker-based classification commonly used in the literature (e.g., Vu and Glewwe, 2022). Specifically, a job is classified as informal if it lacks a written labour contract (or payroll book) and does not provide access to social insurance. This definition includes own-account workers, unpaid family workers, and wage workers without social protection. In contrast, formal employment refers to wage or salaried jobs that include social insurance coverage, primarily in public institutions or registered private enterprises. As an alternative definition, we also adopt the approach used by McCaig and Pavcnik (2015), which classifies informal employment based on the employment setting. Under this approach, a worker is informal if they are self-employed or employed in a household business, as opposed to being employed in a registered enterprise. In Vietnam, state-owned, foreign-invested, and collective firms are legally required to register as enterprises, whereas domestic private firms may legally operate either as registered enterprises or as household businesses.

We present descriptive statistics of the variables used in our empirical analysis in Table 1. Our final sample covers 136,144 individual-level observations spanning the 2014–2020 VHLSS waves. On average, 53.1% of respondents report working informally, though this figure varies considerably (standard deviation = 0.499). Reflecting Vietnam's broader demographic profile, 87.8% of the sample identify as Kinh. The average household size is 4.3, while respondents' mean age is 37 (restricted to 18–54). Approximately 57.6% of the sample are male, and 39% reside in urban areas.

3.2. Internet and lightning strikes data

To measure mobile internet access across Vietnam, we use spatial data on mobile broadband network coverage provided by Collins Bartholomew's Mobile Coverage Explorer. These data are compiled from submissions by mobile network operators to the GSM Association and provide detailed coverage maps for 3G (and, from 2019 onward, 4G) as well as 2G on a global scale. The coverage maps are available at a 1 km × 1 km resolution and indicate whether each grid cell has mobile network coverage in a given year. For this study, we focus on 3G mobile internet, the first generation of wireless infrastructure that supported full internet access, beyond basic text or voice functions offered by 2G. Critically, the available data for Vietnam begin in 2013, a period coinciding with the early phase of the country's accelerated digital expansion.

We aggregate the grid-level coverage data to annual district-level measures of 3G availability, then merge these with the VHLSS at the district level, spanning over 600 districts in Vietnam. The aggregation uses a weighted distance approach to calculate how much of each district is covered by a mobile internet signal annually. One key advantage of this measure is that it captures potential access to mobile broadband, rather than observed usage, making it less likely to be driven by individuals' employment choices. Nonetheless, because network rollout might still follow regional development trends, we address potential endogeneity in our empirical analysis by adopting an instrumental variable strategy, as detailed in Section 4. Table 1 shows that 3G internet coverage averages around 85.9% at the district level, ranging from as low as 3% to full coverage (100%).

As our instrumental variable for internet coverage, information on lightning strike comes from the World Wide Lightning Location Network (WWLLN) (Kaplan and Lau, 2022). The WWLLN data set provides global observations on cloud-to-ground lightning strokes, recorded with sub-kilometer precision and aggregated into gridded climatologies. We use the 2010–2021 global lightning climatology at a 1 km spatial resolution, focusing on lightning strike power. Following the same spatial aggregation approach as for our internet data, we construct district-level measures of average lightning strike power, which we interpret as an exogenous source of variation in telecommunication infrastructure costs.

3.3. Firm data

To complement the household analysis, we draw on the Viet Nam Small and Medium Enterprises (SME) Survey, a biennial panel of non-state manufacturing enterprises conducted since 2005 by the Central Institute for Economic Management (CIEM), the Institute of Labour

Science and Social Affairs (ILSSA), the Development Economics Research Group at the University of Copenhagen, and UNU-WIDER. The survey covers roughly 2,500 enterprises from nine provinces (Hanoi, Hai Phong, Ho Chi Minh City, Phu Tho, Nghe An, Quang Nam, Khanh Hoa, Lam Dong, and Long An), sampled using stratified designs based on the General Statistics Office's establishment census and industrial surveys. The SME data contain rich information on firm performance, history, employment, business environment, and owner/manager characteristics, complemented by an employee module and an economic accounts module. While the SME survey has been conducted since 2005, our firm-level analysis relies on the 2013 and 2015 waves, which can be matched to the internet coverage data used in this study.

Our main variable of interest from the SME survey is the formal status of enterprises, which allows us to examine whether internet expansion is associated with a higher likelihood of firm formalisation. We construct a binary indicator equal to one if a firm is formally registered under the Law on Enterprises and zero if it operates as an unregistered household business. Descriptive statistics reported in Table 1 (Panel C) show that the majority of firms in the sample (72.7%) are formally registered, while only 27.3% operate informally.

4. Empirical strategy

Identifying the causal effect of internet access on informal employment via ordinary least squares (OLS) can be problematic due to endogeneity. First, reverse causality may arise if regions with stronger labour markets are more likely to attract internet infrastructure investment, thus biasing the estimated coefficient on internet coverage. Second, omitted variable bias can occur if unobservable regional characteristics, such as local development potential or unrecorded investments in infrastructure, are correlated with both internet expansion and employment outcomes. To address these concerns, we employ an instrumental variable (IV) approach using the incidence of lightning strikes as a source of exogenous variation in internet availability.

In the first stage, we regress internet coverage (3G coverage) on lightning strike occurrence, controlling for geographic factors (e.g., temperature and precipitation), along with province and year fixed effects. The first stage identifies the component of internet coverage that is attributable solely to variations in lightning strikes, thereby mitigating concerns of reverse causality or omitted variable bias. In the second stage, we regress the probability that a worker works in informal employment on the predicted (i.e., instrumented) value of internet coverage. The regression equations are specified as follows:

$$y_{i,j,t} = \alpha_1 + \beta_1 internet_{j,t} + \gamma_1 x'_{i,j,t} + \sigma_p + \delta_t + \varepsilon_{i,j,t} \quad (1)$$

$$internet_{j,t} = \alpha_2 + \beta_2 lightning_{j,t} + \gamma_2 x'_{i,j,t} + \sigma_p + \delta_t + \epsilon_{i,j,t} \quad (2)$$

where $y_{i,j,t}$ is the outcome (e.g., the probability an individual *i* in district *j* at time *t* works as informal worker), $internet_{j,t}$ is the measured 3G coverage for district *j* at time *t*, $lightning_{j,t}$ is the mean of lightning strikes power, $x'_{i,j,t}$ is a vector of covariates capturing both individual- and district-level characteristics. We also include province fixed effects (σ_p) to account for any time-invariant differences across provinces, such as structural disparities in infrastructure, local governance, or baseline levels of economic development. Similarly, year fixed effects (δ_t) are included to capture common shocks or trends (e.g., changes in national policies or macroeconomic conditions) that affect all provinces in a given year. In all regressions, standard errors are clustered at the district level.

Given the rotating panel structure of the VHLSS, it is not possible to construct a consistent individual panel across all survey waves, and we therefore estimate equations (1) and (2) in a repeated cross-sectional framework. Nonetheless, we exploit the rotating panel component in the 2014–2016 and 2016–2018 waves to run subsample analyses for individuals who are observed in consecutive rounds. In the firm-level analysis, where enterprises are followed over time, we estimate analogous 2SLS specifications and include firm fixed effects. This approach helps control for unobserved, time-invariant heterogeneity at the individual or firm level that could otherwise bias the estimated effects of internet expansion on formalisation.

The choice of lightning strikes as an instrument is based on two key requirements for instrument validity: relevance and exogeneity. First, lightning strikes must have a direct and statistically significant impact on internet coverage (i.e., they predict variation in network rollout). Substantial evidence shows that areas exposed to high-frequency or high-intensity lightning incur greater infrastructure maintenance costs and lower reliability for cell towers (Manacorda and Tesei, 2020; Guriev et al., 2021). Accordingly, telecom providers are less inclined to invest in or expand coverage in these high-lightning regions. Indeed, our first-stage regressions (see Section 5) confirm that lightning prevalence negatively predicts 3G availability.

Second, lightning strikes must not directly affect labour market outcomes except through their impact on internet coverage. Although lightning strikes can occasionally disrupt economic activity, their spatial and temporal distribution is determined primarily by atmospheric conditions rather than local economic factors. Moreover, we explicitly control for potential confounders—such as precipitation, temperature, and fixed effects—to eliminate simultaneous

weather patterns that might otherwise influence employment. Conceptually, lightning-induced outages represent quasi-random shocks to telecommunication service that disrupt internet rollouts in affected regions. Consequently, the variation in 3G coverage induced by lightning strikes is plausibly uncorrelated with unobserved district-level factors driving labour outcomes.

5. Results

5.1. Descriptive analysis

Figure 1 illustrates the evolution of both mobile internet coverage and informal employment across the four surveyed VHLSS waves. Notably, 3G coverage rises sharply, increasing from under 60% in 2014 to over 90% by 2020, a reflection of rapid infrastructure expansion and growing smartphone adoption. In contrast, informal employment exhibits a more modest decline, decreasing from about 55% to slightly under 49% over the same period. Although the direction of change for internet coverage and informal employment suggests a negative relationship between the two, this raw correlation has not yet accounted for other confounding factors, such as regional economic conditions or variations in labour regulations.

5.2. Main findings

Table 2 reports the regression results from both OLS and two-stage least squares (2SLS) specifications, where the dependent variable is a worker's probability of being informally employed. Columns (1) and (2) show the OLS estimates with progressively expanded sets of control variables, while columns (3) and (4) present the corresponding IV estimates. In the OLS models, 3G internet coverage is consistently negative and highly significant, suggesting that districts with higher internet penetration exhibit a lower incidence of informal employment. Including additional covariates (column 2) only slightly alters the magnitude of the coefficient (from −0.279 to −0.268), indicating that the result remains robust to controls for individual- and district-level characteristics, as well as year and province fixed effects. However, interpreting the OLS estimates requires caution, given potential sources of endogeneity such as reverse causality and omitted variables not captured by the regressions.

Turning to the 2SLS estimates, the coefficient on internet coverage remains negative and statistically significant but increases in absolute value (−0.375 in column 3 and −0.647 in column 4), implying that naive OLS may understate the impact of mobile internet coverage on informality. According to our preferred specification (column 4), a one standard deviation increase in 3G internet coverage leads to a 13.5 percentage point reduction in the likelihood of

informal employment, equivalent to a 25.47% decrease relative to the average informal employment rate of 53.1%.

The beneficial effects of internet access in promoting formal employment align with our hypothesis that reliable connectivity improves access to job information, eases skill acquisition (through online tutorials and training) and streamlines the formal hiring process. As more workers in previously under-connected districts can explore formal job listings, submit online applications, and network with prospective employers, the barriers to formalisation decline. These findings are consistent with existing evidence that broadband expansion can boost employment opportunities and productivity (Hjort and Poulsen, 2019; Zuo, 2021; Chiplunkar and Goldberg, 2022; Jin et al., 2023).

Notably, our results stand in contrast to those from Kusumawardhani et al. (2023), who find that increased internet availability, measured as the proportion of villages equipped with internet kiosks, reduces the likelihood of obtaining formal jobs for women in Indonesia. One explanation for this discrepancy may derive from differences in the type of internet infrastructure. Unlike internet kiosks, which primarily offer stationary access points, mobile broadband allows for on-the-go connectivity, thus expanding the range of accessible information and online platforms. Moreover, Indonesia's larger share of low-skill, gig-type internet-based jobs might have pushed female workers into flexible but often still informal services. In Vietnam, by contrast, our focus on mobile internet highlights how broader and more continuous connectivity could facilitate more formal employment pathways.

Table 2 also reports the first-stage of the 2SLS model, confirming that our instrumental variable is strong and valid. In column (4), our preferred specification, lightning strikes have a sizable negative effect on 3G coverage, consistent with the idea that more frequent lightning raises infrastructure maintenance costs and deters network rollout. The weak-instrument test statistic well exceeds standard thresholds, indicating that lightning strikes strongly predict internet availability and thus serve as a plausible instrument.

Although not the primary focus of this study, Table 2 also reports correlations for additional control variables. For example, within the 2SLS framework, ethnicity is positively related to informal employment, and age exhibits a positive coefficient, indicating that older workers are relatively more likely to remain in informal jobs. Likewise, residing in an urban area is linked with greater informality once internet coverage is instrumented, suggesting that urban–rural disparities extend beyond connectivity alone. While these coefficient estimates match expected patterns, they should be interpreted as associations rather than causal effects,

since residual unobserved factors could influence both these characteristics and employment formality.

5.3. Dynamic effects

Figure 2 extends our baseline specification by including lead and lag terms for mobile internet coverage, allowing us to assess the dynamic impact of coverage on informal employment over a two-year horizon before and after the time of reporting. The motivation is twofold. First, if 3G expansion influences labour outcomes only with a delay (e.g., due to workers' learning, job searching, or the slow adoption of e-commerce) then we would expect coverage in the previous year or two years earlier to be more relevant for outcomes measured in the current year. Second, by incorporating leads (i.e., future coverage one and two years ahead), we can conduct a placebo test: if future internet access does not affect current employment, it supports our exogeneity assumption.

The figure plots coefficient estimates for these lead and lag variables with 90% and 95% confidence intervals. The estimates for past coverage (lags) are significantly negative, suggesting that internet expansions in prior years continue to reduce informal employment in subsequent periods, likely reflecting the time required for workers to learn about formal opportunities or acquire the necessary skills. By contrast, the future coverage (leads) terms are close to zero and statistically insignificant, implying that next year's or the following year's rollout of 3G networks has no discernible effect on current informality. Overall, the results highlight a gradual but sustained influence of 3G expansion on the transition away from informal work.

5.4. Heterogeneity analysis

After establishing a significant effect of 3G coverage on informal employment, we examine whether this relationship differs across demographic and household subgroups. Figure 3 reports separate results for each subgroup using 2SLS model.[1] Our first dimension is gender, reflecting the common expectation that women may gain more from better connectivity because they face tighter information and mobility constraints. The figure confirms this expectation: a one-standard-deviation increase in 3G availability lowers the probability of informal employment for women by roughly 15 percentage points, whereas the corresponding estimate for men is essentially zero. A Wald test rejects equality of the two coefficients at the

[1] We also report the estimates in Table A2 (Appendix) along with *p*-values from Wald tests of coefficient equality.

1% level ($p < 0.01$). Expanding mobile broadband therefore appears to be a relatively cost-effective instrument for narrowing gender gaps in job quality by easing women's entry into formal employment.

Turning to age, we split the sample into younger (18–25) and prime-age (26–54) cohorts. In Figure 3, the estimated coefficient for the younger group is considerably more negative, indicating a stronger responsiveness to improved internet access. The equality test reported in Table A1 (Appendix) confirms that the difference between these two groups is statistically significant. One possible explanation is that younger workers are more digitally literate, quicker to adopt online job-matching platforms, and less tied to existing employment arrangements. As a result, they are better positioned to capitalise on new information channels and obtain formal positions more readily than their older counterparts.

We further explore heterogeneity along two additional dimensions: parental status and urban versus rural residence. The results show that the effect of mobile internet coverage is more pronounced among individuals without children, for whom a one standard deviation increase in 3G availability reduces the probability of informal employment by approximately 21 percentage points, compared to about 11 percentage points for those with children. The difference is statistically significant ($p < 0.01$). This suggests that childless individuals, who likely face fewer time and mobility constraints, may be better able to take advantage of digital resources to access formal job opportunities. A similar pattern emerges when comparing rural and urban areas. While both groups exhibit negative coefficients, the effect in urban areas is nearly three times larger than in rural areas (–1.241 vs. –0.404). One possible explanation is that urban labour markets offer a wider range of formal employment opportunities that become more accessible as internet infrastructure improves. These findings underscore the importance of context in shaping the returns to digital connectivity and suggest that broadband expansion may have especially strong formalising effects in urban environments and among individuals facing fewer household constraints.

Finally, we also examine heterogeneity by income and education, two key dimensions of inequality in developing labour markets.[2] We classify income groups based on the median cutoff of household income per capita, while education is defined as below high school versus high school or above. The results indicate that high-income individuals benefit disproportionately from internet expansion: a one standard deviation increase in 3G coverage reduces their probability of informal employment significantly more than for low-income

[2] Our main analysis does not control for income or education given their potential endogeneity.

individuals. This gap, statistically significant at the 5% level, suggests that wealthier workers may be better positioned to exploit digital resources due to complementary advantages such as higher baseline skills, better access to technology, or stronger labour market connections. Similarly, the effects are larger among those with higher education relative to their less-educated counterparts. Education likely enhances digital literacy and job-search effectiveness, thereby strengthening the gains from improved connectivity.

5.5. Robustness tests

To assess the robustness of our main findings, we conduct a series of sensitivity tests, reported in Table 3. These checks are designed to examine whether the estimated effects of 3G internet access on informal employment hold under alternative specifications and sample restrictions.

We begin in Column (1) by testing whether earlier-generation mobile infrastructure, specifically 2G internet, has any discernible effect on informality. Unlike 3G, which enables full internet access including web browsing and app usage, 2G networks primarily support basic voice calls and text messaging, with extremely limited data capabilities. As such, 2G is unlikely to facilitate online job searches, digital skill acquisition, or access to formal employment platforms in the same way 3G does. Consistent with this intuition, we find no statistically significant relationship between 2G coverage and informal employment; the estimated coefficient is negative but close to zero and imprecisely estimated.

In Column (2), we test the robustness of our results using an alternative measure of internet access that accounts for population exposure rather than just geographic coverage. While the main analysis defines internet availability as the share of a district's area covered by 3G signal, this approach may overstate effective access in sparsely populated or uninhabited regions. To better capture how many people are likely to benefit from mobile internet, we construct a population-weighted measure that incorporates population density at the grid level. Specifically, we use gridded population data from Lloyd et al. (2017) to calculate population-weighted 3G availability for each district in Vietnam. This adjustment allows us to account for differences in where people actually live within a district, providing a more accurate proxy for potential user exposure to internet infrastructure. The results in Column (2) show that even when using this population-adjusted metric, the effect of 3G coverage on informal employment remains strong and statistically significant.

In Column (3), we test the robustness of our results using an alternative definition of informal employment. While our main analysis follows Vu and Glewwe (2022), identifying informal jobs as those without a payroll book and lacking access to social insurance, this

specification adopts the classification used by McCaig and Pavcnik (2015). Under this alternative approach, a worker is considered informal if they are self-employed or employed in a household business, rather than in a registered enterprise. This setting-based definition provides a broader institutional perspective on informality. The results remain robust under this alternative classification, with the estimated effect of 3G coverage on informal employment continuing to be negative and statistically significant.

In the next two columns, we examine the sensitivity of our findings to different sample restrictions. Column (4) excludes individuals working in agriculture, a sector where informal employment is pervasive and where formalisation dynamics may differ from those in non-agricultural sectors. Agricultural work often takes place in smallholder or family-run operations, where the applicability of internet-enabled job search or formal work arrangements is limited. By removing these observations, we focus the analysis on sectors where digital access is more plausibly linked to formal job opportunities. Column (5) takes the opposite approach by excluding respondents from Vietnam's two largest cities, Hanoi and Ho Chi Minh City, where informality rates are relatively low and internet penetration is already near universal. Excluding these urban outliers allows us to assess whether the observed effects are driven solely by densely populated urban centres, or whether they hold more broadly across the country. In both cases, the estimated effect of 3G coverage on informal employment remains negative and statistically significant, though slightly attenuated in magnitude.

In Column (6), we further strengthen our identification strategy by adding province-specific linear time trends to the model. While the main specification already includes province fixed effects and year fixed effects to control for time-invariant regional characteristics and nationwide shocks, respectively, this additional control captures any differential trends across provinces that could simultaneously influence both internet expansion and informal employment. For example, provinces experiencing faster structural transformation or labour market development might also be more likely to receive infrastructure investments, including digital connectivity. By allowing each province to have its own trend over time, we account for such gradual, unobserved changes. The coefficient on 3G coverage remains negative and statistically significant, indicating that the observed relationship is not simply driven by underlying province-level trends in labour market formalisation.

Column (7) introduces industry fixed effects, addressing concerns that unobserved differences across sectors—such as industry-specific trends in technology adoption, labour regulation, or demand shifts—might confound the estimated effects. Including these controls ensures that identification comes from within-industry variation in internet expansion. The

results remain robust, with a negative and statistically significant coefficient. Column (8) adds controls for nightlight intensity, a widely used proxy for local economic activity and development (e.g., Hodler and Raschky, 2014; Henderson et al., 2018). This test addresses the concern that the observed effects could be capturing broader growth dynamics, rather than internet-specific effects. By controlling for nightlights, we net out variation linked to general economic development, providing a more stringent test of the role of digital connectivity. The results continue to show a strong negative association between 3G coverage and informal employment.

Finally, in Column (9), we address the potential concern of spatial spillover effects—that is, the possibility that mobile internet expansion in one district may influence labour market outcomes in neighbouring districts. For example, workers may commute across district boundaries, or firms and job search platforms may operate across wider geographical areas, making local estimates potentially biased if spatial correlation is ignored. To account for this, we implement a Conley (1999) spatial correction, which adjusts standard errors to allow for spatial autocorrelation in the residuals based on geographic distance between observations. The results continue to show a negative and statistically significant relationship between 3G coverage and informal employment.

5.6. Panel analysis

A limitation of our main analysis is that it relies primarily on repeated cross-sectional data, which captures average differences in informal employment across districts with varying levels of internet coverage. While this approach is informative, it does not directly track transitions between informal and formal employment within the same individuals over time. Understanding these transitions is particularly important in the context of structural change in developing labour markets, as the benefits of internet expansion may arise not only through differences across individuals, but also through changes in job status within individuals.

To address this issue, we exploit the rotating panel feature of the VHLSS, which allows a subset of individuals to be followed for two consecutive survey rounds. Specifically, we construct short two-year panels for the 2014–2016 and 2016–2018 periods. Although the survey design does not permit a consistent long panel across all waves, these subsamples provide an opportunity to estimate models with individual fixed effects, thereby focusing on within-person changes in employment formality as 3G coverage expands. Table 4 reports the 2SLS estimates from this panel specification. The results are consistent with our baseline findings: greater 3G coverage significantly reduces the probability of informal employment

even after conditioning on time-invariant individual characteristics. The coefficient magnitudes are somewhat smaller than those in the cross-sectional analysis, which is expected given the shorter observation window and reduced sample size. Nonetheless, the estimates remain statistically significant and negative, highlighting that the effects of internet expansion are not merely driven by compositional differences across districts or individuals, but also reflect genuine transitions from informal to formal work within individuals.

5.7. Mechanism: firm formalisation

Our current analysis has focused primarily on the worker side of the labour market, examining how expanded mobile internet coverage shapes individuals' transitions between informal and formal employment. Yet, the supply side is equally important: the creation of formal job opportunities depends on firms' ability and willingness to operate within the formal sector. Internet expansion may directly influence this process by lowering transaction costs, improving access to customers and suppliers, and reducing the administrative burden of complying with formal regulations. In this sense, a key mechanism linking connectivity to individual labour outcomes is the formalisation of firms themselves.

To examine this channel, we turn to the Vietnam SME survey, which provides rich panel data on enterprises over time. We exploit the panel structure of the survey and estimate 2SLS models with firm fixed effects, thereby identifying the effect of internet expansion on within-firm changes in formality status. Table 5 reports the results. Conditional on other firm characteristics, our estimates show that greater mobile internet coverage is associated with a significantly higher likelihood of firms becoming formal, consistent with the hypothesis that internet expansion encourages formalisation on the supply side. Specifically, a one standard deviation increase in internet coverage raises the probability of a firm operating formally by 9.8 percentage points, equivalent to a 13% increase relative to the mean (Column 2). These findings suggest that digital infrastructure not only facilitates individual transitions into formal employment but also expands the pool of formal opportunities by incentivising firms to formalise.

6. Conclusions

This paper addresses the important question of whether expanded mobile internet services can effectively facilitate workers' transition from informal to formal jobs in a rapidly developing economy like Vietnam. Large informal sectors expose workers to greater vulnerability, so policies that reduce barriers to formalization have significant social and economic implications.

By focusing on mobile broadband coverage, a key digital infrastructure during a period of rapid expansion, our study highlights a potentially powerful avenue for encouraging more stable and legally protected forms of employment.

Our main finding is that greater 3G coverage, instrumented by regional lightning strikes, substantially lowers informality rates. The 2SLS estimates exceed the OLS magnitudes, suggesting that simpler correlations understate the true impact of internet access. We find that demographic subgroups, including different genders and age cohorts, benefit in broadly similar ways, indicating that basic internet connectivity can serve as a relatively inclusive platform, reducing reliance on informal work across a wide range of workers. Moreover, we show that internet expansion fosters firm formalisation on the supply side: evidence from the SME survey indicates that higher 3G coverage significantly increases the likelihood that enterprises operate formally. Together, these results suggest a dual channel through which digital infrastructure promotes labour market formalisation—by enabling workers to access formal jobs more effectively and by incentivising firms to generate more of these opportunities.

From a policy perspective, our results underscore the promise of digital infrastructure in addressing labour market vulnerability. However, reaching these gains may call for additional measures. Digital training programs could help individuals acquire the skill sets needed to leverage online job searches or remote work. Initiatives to simplify e-contracts and business registration could further reduce the costs of transitioning to formal status. Local conditions, including terrain and lightning risk, continue to shape how infrastructure providers determine rollout priorities, so place-based or targeted interventions may be essential for especially underserved districts.

Our analysis has some limitations. Our measure of internet access centres on basic coverage rather than signal quality or the actual intensity of use. Regions can have near-complete coverage but poor speeds or reliability, which may constrain employment benefits in practice. In addition, we do not fully unpack the mechanisms linking coverage to the formalization process. Future research could quantify the extent to which online skill acquisition, job posting platforms, or e-signatures for employment contracts matter for formal hiring, as well as how new gig-oriented internet jobs compare in earnings and worker protections to more conventional formal positions. Investigating potential general-equilibrium repercussions, such as how broader formalisation might affect wages and job creation within the informal economy, would also deepen our understanding of technology's role in structural transformation.

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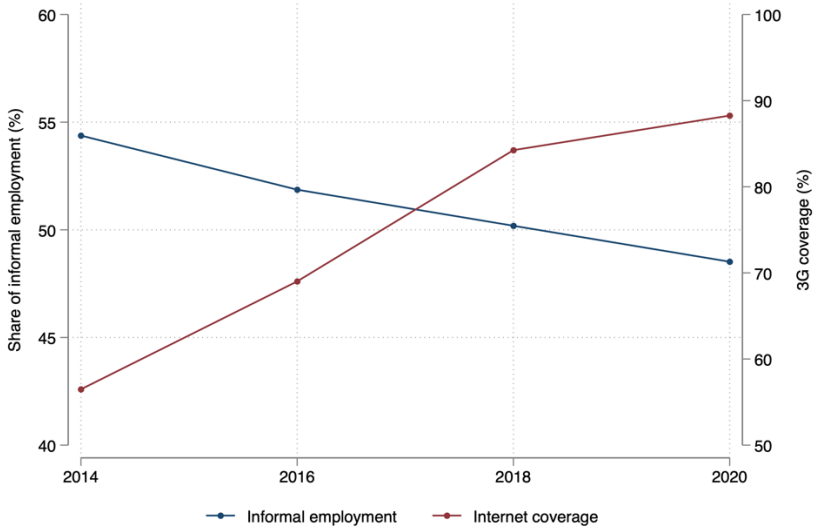
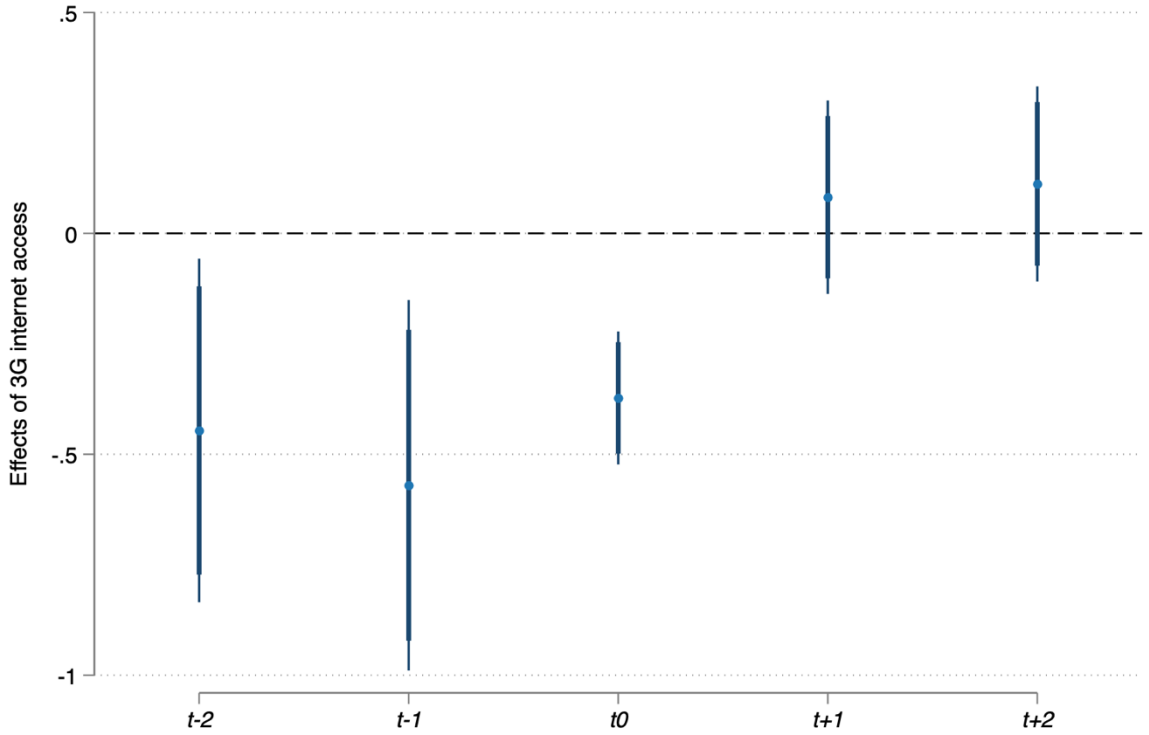
Figures and Tables

Figure 1: Informal payment and mobile internet coverage over time



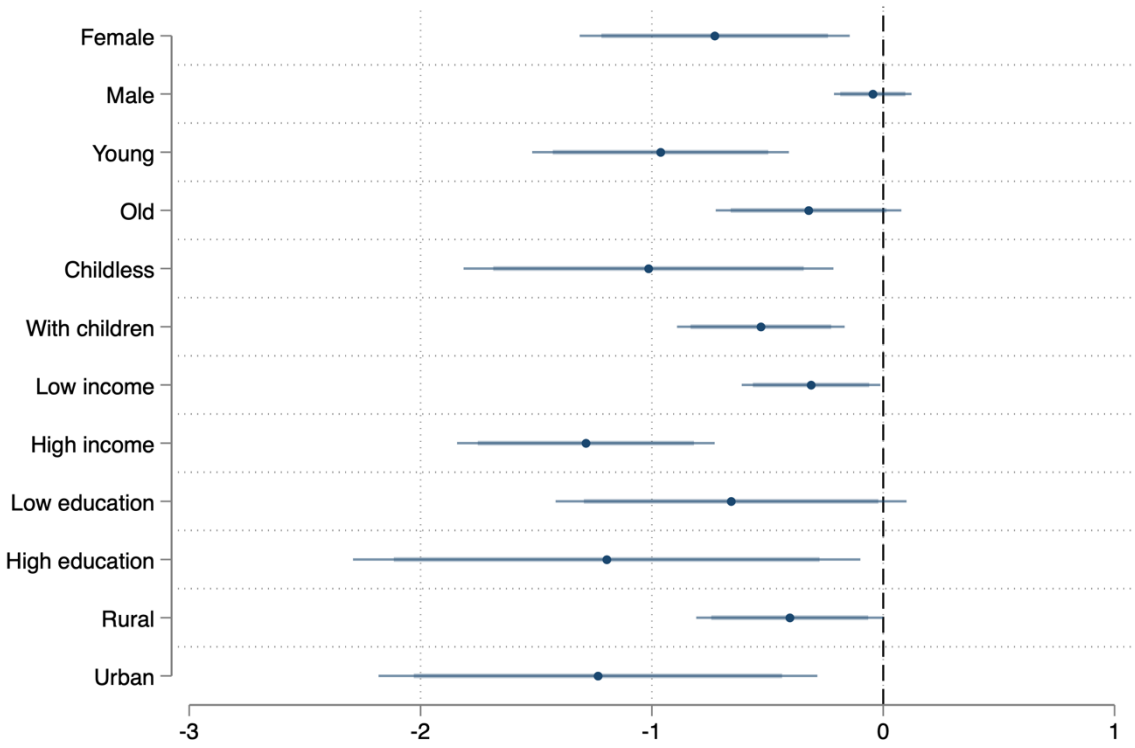
Notes: The figures show the average coverage of 3G internet and the share of informal employment from 2014 to 2020. The internet data is provided by Collins Bartholomew Mobile Coverage Explorer, and the employment data is sourced from the VHLSS.

Figure 2: Effects of mobile internet on informal employment – Controlling for Lead and Lag Effects



Notes: The figure shows the coefficient estimates from a linear probability event study regression, controlling for age, age squared, ethnicity, gender, household size, living area, employment status, district temperature and rainfall, year fixed effects, and province fixed effects. The 90% and 95% confidence intervals are based on standard errors clustered at the district level. The internet data is provided by Collins Bartholomew Mobile Coverage Explorer, and the employment data is derived from the VHLSS.

Figure 3: Effects of mobile internet on informal employment – Heterogeneity analysis



Notes: The figure shows the effect heterogeneity for selected characteristics: gender (male vs female), whether individuals below 25 or above 25, living in household with or without children, and living in rural vs urban areas. The coefficient estimates and 90% (95%) confidence intervals (CIs) are derived from regressions that include age, age squared, ethnicity, gender, household size, living area, employment status, district temperature and rainfall, year fixed effects, and province fixed effects.

Table 1: Effects of mobile internet on informal employment – Summary statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
Panel A: Household data					
Informal employment	136,144	0.531	0.499	0.000	1.000
Ethnicity (Kinh=1)	136,144	0.878	0.328	0.000	1.000
Household size	136,144	4.287	1.559	1.000	16.000
Age	136,144	37.018	11.765	18.000	54.000
Gender (male=1)	136,144	0.576	0.494	0.000	1.000
Urban areas	136,144	0.389	0.487	0.000	1.000
Panel B: Internet and weather data					
3G internet coverage	706	0.859	0.209	0.030	1.000
Lightning strike	706	0.004	0.003	0.000	0.020
Temperature	706	25.809	1.966	18.774	28.768
Rainfall	706	5.565	1.104	2.056	11.831
Panel C: Firm data					
Formal firm	2,663	0.727	0.445	0.000	1.000
Revenue (log)	2,663	13.047	1.457	0.000	17.256
Number of fulltime workers (log)	2,663	1.411	0.545	0.000	4.190
Years since establishment	2,663	17.600	10.278	2.000	61.000

Table 2: Effects of mobile internet on informal employment – Baseline results

Dependent variable:	OLS	OLS	2SLS	2SLS
Informal employment	(1)	(2)	(3)	(4)
3G internet	-0.279***	-0.268***	-0.375***	-0.647***
	(0.009)	(0.007)	(0.104)	(0.168)
Ethnicity (Kinh=1)		-0.177***		0.231***
		(0.004)		(0.012)
Household size		-0.006***		0.009***
		(0.001)		(0.001)
Age		-0.017***		0.016***
		(0.001)		(0.001)
Age squared		0.000***		-0.000***
		(0.000)		(0.000)
Gender (male=1)		0.163***		-0.157***
		(0.003)		(0.003)
Urban area		-0.196***		0.205***
		(0.003)		(0.007)
Temperature		0.034***		0.077***
		(0.001)		(0.018)
Rainfall		0.001		-0.013***
		(0.001)		(0.003)
First-stage of 2SLS				
Lightning strike			-6.833***	-4.148***
			(0.210)	(0.190)
Weak instrument statistic			61.543	75.061
Year FEs	Yes	Yes	Yes	Yes
Province FEs	Yes	Yes	Yes	Yes
Observations	136,144	136,144	136,144	136,144

Notes: Robust standard errors in parentheses. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Effects of mobile internet on informal employment – Robustness tests

Dependent variable:	2G internet	# measure of internet	# measure of informal employment	Excluding agriculture	Excluding big cities	Province-year FEs	Industry FEs	Controlling for nightlight	Conley regression
Informal employment	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
2G internet	-2.018								
	(1.875)								
3G internet		-0.896***	-0.411**	-0.410**	-0.366***	-0.526***	-0.616***	-0.585***	-0.252***
		(0.240)	(0.198)	(0.180)	(0.093)	(0.114)	(0.121)	(0.165)	(0.084)
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	136,144	136,144	136,145	121,956	121,719	136,144	136,144	136,144	136,144

Notes: Robust standard errors in parentheses. Other controls include ethnicity, household size, age, age squared, gender, urban area, district temperature and rainfall. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 4: Effects of mobile internet on informal employment – Panel analysis

Dependent variable:	2014-2016	2016-2018
Informal employment	(1)	(2)
3G internet	-0.897**	-0.869***
	(0.406)	(0.302)
First-stage of 2SLS		
Lightning strike	-8.951***	-8.156***
	(1.214)	(0.751)
Weak instrument statistic	54.349	117.799
Year FEs	Yes	Yes
Individual FEs	Yes	Yes
Observations	5,738	12,852

Notes: Robust standard errors in parentheses. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Effects of mobile internet on firm formalisation

Dependent variable:	Firm formalisation	
	(1)	(2)
3G internet	0.451***	0.467***
	(0.170)	(0.166)
Revenue (log)		-0.026***
		(0.006)
Number of workers (log)		-0.100***
		(0.017)
Number of years since establishment		-0.003***
		(0.001)
Temperature		-0.169***
		(0.020)
Rainfall		-0.016
		(0.018)
First-stage of 2SLS		
Lightning strike	-31.319***	-31.406***
	(1.046)	(1.046)
Weak instrument statistic	73.176	76.093
Year FEs	Yes	Yes
Firm FEs	Yes	Yes
Observations	2,667	2,663

Notes: Robust standard errors in parentheses. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Appendix

Table A1: Effects of mobile internet on informal employment – Reduced form

Dependent variable:	Informal employment	
	(1)	(2)
Lightning strike	2.294***	2.368***
	(0.696)	(0.681)
Ethnicity (Kinh=1)		0.189***
		(0.005)
Household size		0.009***
		(0.001)
Age		0.016***
		(0.001)
Age squared		-0.000***
		(0.000)
Gender (male=1)		-0.157***
		(0.003)
Urban area		0.178***
		(0.003)
Temperature		0.007***
		(0.002)
Rainfall		-0.005***
		(0.002)
Year FEs	Yes	Yes
Province FEs	Yes	Yes
Observations	136,144	136,144

Notes: Robust standard errors in parentheses. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1

Table A2: Effects of mobile internet on informal employment – Heterogeneity analysis

Dependent variable:	Female	Male	Young	Old	Childless	With children	Low income	High income	Low education	High education	Rural	Urban
Informal employment	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
3G internet	-0.729**	-0.045	-0.963***	-0.323	-1.015**	-0.529***	-0.312**	-1.286***	-0.658*	-1.196**	-0.404*	-1.233**
	(0.298)	(0.086)	(0.283)	(0.205)	(0.408)	(0.185)	(0.153)	(0.284)	(0.387)	(0.559)	(0.206)	(0.484)
Equality test (*p*-value)	<0.001		<0.001		0.048		0.030		<0.001		0.001	
Other controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	57,657	78,487	24,700	111,444	36,782	99,362	69,066	67,078	34,823	29,301	83,244	52,900

Notes: Robust standard errors in parentheses. Other controls are the same as in Column (4) of Table 2, except when they are used to define subgroups for the heterogeneity analysis. Standard errors are clustered at the district level. *** p<0.01, ** p<0.05, * p<0.1