Digital Beginnings: Labor-Market Transformation at the Onset of Connectivity

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Abstract

We study the labor market consequences of the rollout of second-generation mobile networks across 2,040 regions in thirteen developing countries between 1990 and 2015. To address endogenous network placement, we exploit exogenous variation in signal disruptions caused by lightning strikes as an instrument for regional coverage. A fifty percentage point increase in coverage raises labor force participation and employment by about one-third of baseline levels. Coverage reallocates workers from self-employment toward wage jobs and, to a lesser extent, unpaid activities, with apprenticeships accounting for most of the latter. Sectoral estimates show persistent gains in agriculture, while manufacturing and services display smaller or insignificant responses. Within agriculture, new workers are absorbed mainly through wage contracts. Connectivity also increases secondary school attainment and amplifies wage employment gains in regions specialized in tradable activities. These findings show that even basic mobile networks reshaped labor markets at the onset of digital integration, highlighting that the economic consequences of digital infrastructure depend on the technological frontier.

Keywords: Mobile Connectivity; Labor Markets; Structural Transformation; Digital Infrastructure
JEL Codes: O33, O14, O12, J21, L96

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1. Introduction

How does the ability to communicate instantly across distance shape labor market dynamics? Technological progress has repeatedly transformed how people connect and work. For much of the developing world, this transformation began only in the late 1990s and early 2000s, when second-generation (2G, GSM) mobile networks first became available.[1] These systems enabled basic voice calls and text messages at very low cost, marking the first opportunity for real-time communication in large parts of the world. This early stage of digital connectivity offers a unique context to examine how communication technologies reshape labor markets. The arrival of second-generation networks represented a sharp decline in communication costs and, for many households, the first entry point into the digital economy (Aker and Mbiti, 2010). While later generations of mobile technology have attracted substantial attention for expanding internet access and data use (Guriev et al., 2021; Adema et al., 2022), we know far less about how these initial, non-internet forms of connectivity affected labor markets in previously disconnected economies. We ask how the rollout of 2G networks influenced employment structures in newly connected regions, and what this reveals about how the economic effects of digital infrastructure depend on the technological frontier.

In this paper, we examine how the diffusion of second-generation (2G) mobile networks affected labor markets in the developing world. We combine, georeferenced data on the timing and spatial distribution of mobile coverage with harmonized labor force surveys across twelve countries. To identify the causal effects of connectivity, we estimate a two-way fixed effects model in a long-difference framework, instrumenting for 2G availability with exogenous variation in lightning strike frequency that affected the cost of network expansion. Our results show that 2G rollout increased overall employment, with pronounced gains in services and among women, while leaving agricultural and self-employment shares largely unchanged. These findings indicate that even basic, non-Internet communication technologies facilitated labor reallocation and market participation, underscoring the transformative potential of early digital connectivity.

To answer this question, we assemble IPUMS labor-market and socio-economic data for 2,040 administrative regions across thirteen countries in Africa, Asia, and Latin America between 1990 and 2015. We combine regional labor outcomes with spatial measures of 2G mobile coverage over two survey waves. To establish causality, we exploit natural variation in signal reliability: lightning strikes impair wireless signal propagation and damage transmission towers, creating local fluctuations in coverage unrelated to economic activity (Manacorda and Tesei, 2020). We instrument regional mobile coverage with lightning incidence. This strategy yields plausibly exogenous variation in access to mobile networks, allowing us to identify the causal impact of early communication technology on employment and labor market composition.

[1] GSM (Global System for Mobile Communications) is a widely adopted standard that laid the foundation for international roaming and subsequent network generations.

We present findings across four main labor market outcomes: labor force participation (LFP), employment, sectoral employment and employment type shares. In addition, we also run heterogeneity analysis, looking at differential impacts in regions with different trade orientations and in gendered samples.

Starting with the LFP and Employment shares findings. A 50 percentage point increase in regional 2G coverage raises labor-force participation and employment by roughly one-third of baseline levels. These gains are driven primarily by new entrants into the labor market rather than by higher employment among those already active. Ordinary least squares estimates are near zero, while reduced-form regressions show that lightning strikes reduce both coverage and employment, supporting a causal interpretation of the instrumental-variable estimates.

Moving to the employment sectors and types shares results. The expansion of mobile coverage also reshapes the composition of employment. Self-employment remains broadly stable, while wage work rises substantially, and unpaid work-often apprenticeships increase sharply. The largest gains occur in agriculture, with limited changes in manufacturing and modest increases in services. We zoom into single sectors to obtain more granular insigths.Within sectors, agriculture absorbs additional workers through wage contracts, manufacturing through family-based activities, and services through informal positions.

A more detailed classification confirms this reallocation. Wage employment expands through both day labor and permanent positions, accompanied by a shift from private and domestic service toward public and parastatal roles. Apprenticeships increase as family unpaid work declines.

Coverage also raises secondary-school attainment and strengthens wage-employment gains in regions with a larger share of tradable activities, suggesting that information and education channels, together with production orientation, shape the impact of mobile connectivity.

Sectoral heterogeneity reinforces these patterns. In agriculture, wage employment increases and self-employment declines. Manufacturing shows modest overall changes but more family-based work, while services experience small rises in self-employment and unpaid activities. These results point to an early stage of labor market formalization, with employment shifting toward wage contracts, training arrangements, and selected service and agricultural activities.

The results are robust to a range of alternative specifications and falsification tests. A key concern is that rainfall, which affects both network expansion and employment outcomes, could act as a potential collider. We address this by explicitly controlling for rainfall, both in levels and as a time-varying measure, and find that our estimates remain stable. In addition, a placebo exercise that assigns the rollout of 2G networks ten years prior to their actual introduction yields no significant effects, reinforcing the causal interpretation of our results. The findings are further robust to the inclusion of extended geographic and socio-demographic controls, as well as to alternative sets of fixed effects.

Our paper contributes to a growing literature on how communication and digital infrastructure shape economic outcomes. Hjort and Tian (2025) provides a comprehensive survey of this field, documenting the wide-ranging effects of internet connectivity on productivity, employment, and welfare. Within this broader literature, our study lies at the intersection of three strands.

The most closely related work is Chiplunkar and Goldberg (2022), who examine the effects of mobile internet expansion using the same underlying data source and finds large employment gains driven by improved internet access. A broader literature explores how higher-speed or more advanced digital infrastructure affects labor markets. Hjort and Poulsen (2019) shows that submarine cable connections improving internet speeds raised employment, particularly among higher-skilled workers, while Goldbeck and Lindlacher (2024) finds large employment gains following the initial arrival of basic fixed-line internet, especially in services and agriculture. Studies focusing on one country that report increases in labor-force participation, reallocation toward more productive sectors, and improved job search efficiency (Bahia et al., 2021, 2024; Caldarola et al., 2022). In advanced economies, broadband availability is generally associated with positive employment and skill upgrading (Akerman, Gaarder, and Mogstad, Akerman et al.; Atasoy, 2013), though the evidence remains mixed (Czernich, 2014). We differ by focusing on an earlier stage of technological diffusion-the rollout of second-generation (2G) networks-which provided voice and text connectivity but no internet. This distinction allows us to isolate the effects of basic communication rather than broadband adoption

Compared with mobile internet and broadband, the earlier phase of mobile diffusion has received far less attention. A small set of studies provides microeconomic evidence on the 2G era. Jensen (2007) shows that mobile phones reduced price dispersion in Indian fish markets, and Aker and Mbiti (2010) documents improved market efficiency for grain prices in Niger. Manacorda and Tesei (2020) find that mobile coverage facilitated political mobilization and protest. We build on this line of work by shifting the focus from market efficiency and political outcomes to labor markets and by exploiting multi-country variation to estimate causal effects on employment structures. A related branch studies mobile money, a technology that builds on but does not require internet connectivity. Starting with Jack and Suri (2014), researchers have shown that mobile money improves risk sharing and household welfare. Because mobile money services such as M-Pesa emerged only after 2007 and remained limited in reach during the 2G rollout period we study, they play little role in our setting, which captures an earlier communication-only phase of technological change.

Finally, our work connects to the extensive literature on non-digital infrastructure and labor markets. Studies of roads and railways document large employment and productivity effects through market access and migration channels (e.g., Asher and Novosad, 2020; Banerjee et al., 2020; Donaldson, 2018; Michaels, 2008), while research on electrification highlights gendered and sector-specific responses (e.g., Dinkelman, 2011; Moneke, 2020). This body of work shows

that infrastructure investments can trigger major shifts in employment composition and geographic distribution-mechanisms that are central to our analysis of digital connectivity.

Our paper provides the first multi-country evidence on how early mobile connectivity reshaped labor markets in developing economies. Using harmonized microdata, we document consistent increases in participation and employment, alongside large reallocations from self-employment toward wage work and apprenticeships. By contrasting these effects with those found for later digital technologies, we show that the labor-market consequences of digital infrastructure depend on the technological frontier: while broadband primarily expands service-sector employment, early mobile communication strengthened traditional sectors and lowered barriers to formal wage work.

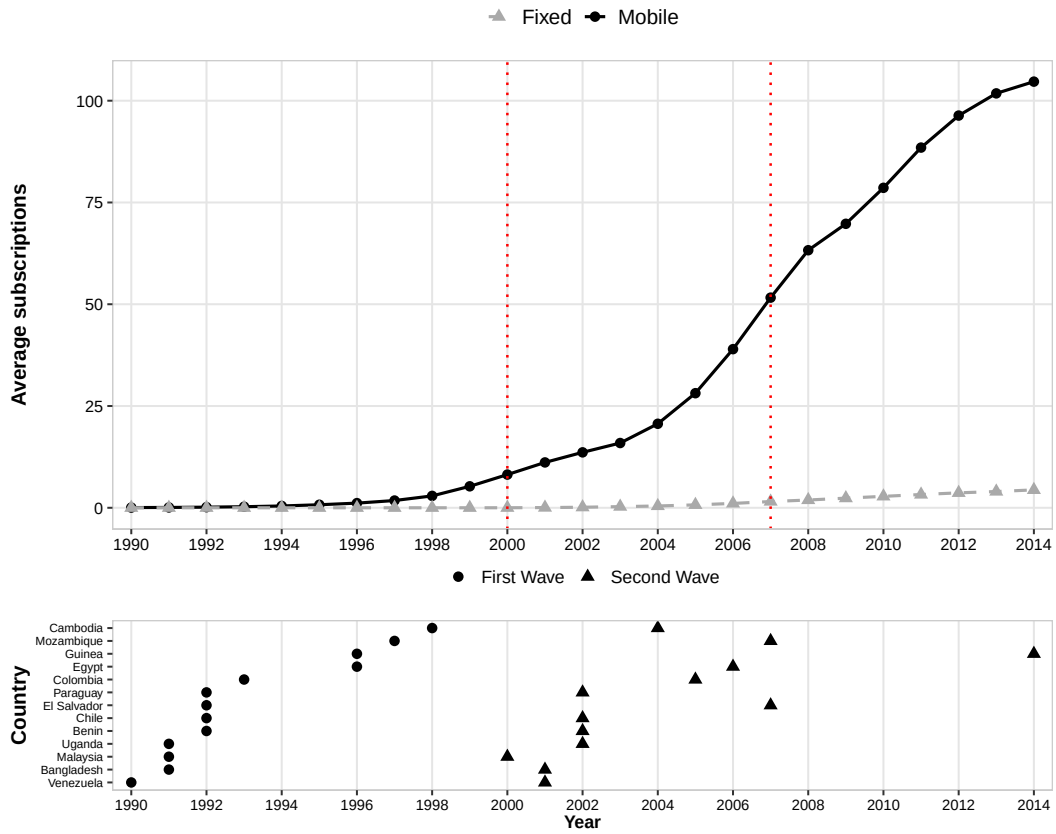
The remainder of the paper proceeds as follows. In Section 2 we describe institutional context of our analysis; in Section 3, we detail our empirical framework and identification strategy. Section 4 describes the construction and sources of our dataset and variables. In Section 5 we lay out the conceptual framework that we use to interpret our core results on labor market outcomes, sectoral shifts, and employment types that are presented in Section 6, while Section 7 explores mechanisms and heterogeneities. Finally, Section 8 summarizes our findings and discusses their implications.

2. Measuring Access to Mobile Network

The spread of second-generation mobile networks in the late 1990s and early 2000s marked a decisive shift from fixed-line telephony to digital communication. The new digital systems enabled clear voice calls, text messaging, and limited data transmission at much lower cost and with greater reliability than the analog technologies that preceded them. In the economies we study, telecommunications infrastructure before this transition was minimal, and fixed-line access reached only a very small share of the population.

Figure 1 illustrates this transformation. The upper panel plots average mobile and fixed line subscriptions per 100 inhabitants across the thirteen countries in our sample. Mobile adoption accelerated sharply during the period, rising from fewer than five subscriptions per 100 inhabitants in 1995 to more than twenty-five by 2005. In the same years, fixed-line connections remained under ten percent of coverage in the countries in our sample. The lower panel marks the timing of the survey waves we employ in our empirical setting, showing that almost no individual had mobile access in the first wave, while a substantial share did by the second (Table G2). These patterns confirm that the diffusion of second-generation networks marked the first widespread opportunity for real-time communication in the study countries. While the top panel of the figure reports mobile phone subscription rates to illustrate the broader trajectory of adoption, our empirical strategy does not rely on usage or adoption measures. Instead, we exploit exogenous variation in network availability to identify the effects of access to communication infrastructure..

Figure 1: Average in Sample % Change in Mobile and Fixed line subscriptions



Notes: ITU Data on mobile subscriptions and fixed-line subscriptions per 100 individuals averaged by year within the countries in our sample (13). The bottom panel reports the two years where each country is observed in the study in the first and second waves, respectively.

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Distinguishing 2G networks from later mobile technologies is crucial for our analysis. Third-generation and broadband systems differ sharply in speed, capacity, and purpose (ITU, 2025). While they support internet use, multimedia communication, and data-intensive services, second-generation networks mainly lowered the cost of basic voice and text communication. This narrower technological scope is analytically beneficial, allowing us to identify the initial impact of simple mobile connectivity on labor market outcomes before the complexities of subsequent technological generations that granted widespread internet access. We focus on this window, characterized by negligible fixed-line access and the absence of mobile internet, as a quasi-natural experiment that isolates the effect of basic, real-time communication on labor markets.

3. Identifying the Effect of Mobile Connectivity

We identify the causal effect of second-generation mobile coverage on labor market outcomes using an instrumental variables strategy. Following Manacorda and Tesei (2020) and Guriev

et al. (2021), we instrument regional 2G coverage with exposure to lightning strikes, which disrupt network reliability and impede infrastructure deployment. The design exploits within-continent, within-region changes between two survey waves in a long-difference framework, with region fixed effects and continent-by-wave fixed effects. We control for baseline rainfall to absorb correlated climatic conditions, and for the sociodemographic and geographic characteristics of regions, and we show robustness to alternative control sets in subsequent specifications.

3.1. Baseline Specification

We begin by estimating simple Ordinary Least Squares (OLS) regressions of regional labor market outcomes on 2G mobile coverage to document the unconditional relationship between connectivity and employment patterns. Specifically, we estimate:

$$Y_{rc(r)w} = \alpha + \beta_1 2G_{rw} + \text{rain}'_r\beta_w + X'_{rw}\gamma + \mu_r + \mu_{c(r)w} + \epsilon_{rc(r)w}, \tag{1}$$

where $Y_{rc(r)w}$ denotes the labor market outcome in region r (in continent $c(r)$) observed in survey wave $w \in \{1, 2\}$. The key explanatory variable, $2G_{rw}$, measures the share of the regional population living within 2G network coverage. The control vector X_{rw} included the set of controls we choose to include our main specification: time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins). Each of these controls is interacted with survey-wave dummies to allow their associations with employment outcomes to vary over time. Baseline rainfall, measured in 1990 and interacted with wave dummies, captures long-run climatic conditions potentially correlated with both lightning activity and labor market activity.[2]

Region fixed effects (μ_r) absorb all time-invariant local characteristics, while continent-by-wave fixed effects ($\mu_{c(r)w}$) control for macroeconomic and institutional changes common to all regions within a continent. Identification thus relies on within-continent, within-region changes over time. Cross-sectional differences across regions and time-varying continent-wide shocks do not contribute to identification. Standard errors are two-way clustered at the region and country-year levels following Guriev et al. (2021).

We estimate the model for each country over two waves in a balanced panel: a pre-rollout period in the 1990s and a post-rollout period in the 2000s.

As shown in Table G2, all countries are observed after 2G introduction and before 3G diffusion, ensuring that our estimates capture the effects of basic mobile connectivity rather than internet-enabled technologies.

[2] We also show robustness to specifications including time-varying rainfall and socio-demographics(Table B1).

3.2. *Instrumental Variable Design: Lightning Strikes and Network Reliability*

While the OLS specification in Equation 1 provides a useful benchmark, the deployment of 2G infrastructure is likely endogenous. Regions that are more economically developed or possess complementary infrastructure, such as electrification networks, road connectivity, or higher population density, may both attract mobile network investment and exhibit stronger labor market performance. Consequently, OLS estimates may capture these confounding dynamics rather than the causal effect of mobile coverage.

To address this concern, we implement a Two-Stage Least Squares (2SLS) strategy using lightning strike frequency as an instrument for 2G mobile coverage. Lightning strikes provide a plausibly exogenous source of variation: high-voltage discharges can damage base stations, antennas, and power lines, degrading or delaying network installation. This approach follows Manacorda and Tesei (2020), who first proposed lightning exposure as a predictor of 2G availability, and related studies employing similar logic for 3G rollout (Guriev et al., 2021; Caldarola et al., 2022; Mensah, 2023). The key identifying assumption is that lightning strikes affect labor market outcomes only through their impact on network reliability and expansion, satisfying the exclusion restriction.

We specify the first stage of the 2SLS estimation as:

$$2\text{G}_{rc(r)w} = \pi_0 + \pi_1 \cdot \text{Lightning Strikes}_{rc(r)w} + \text{rain}_r'\pi_w + X_{rw}'\pi + \mu_r + \mu_{c(r)w} + \epsilon_{rc(r)w}, \tag{2}$$

where $\text{Lightning Strikes}_{rc(r)w}$ denotes the population-weighted mean lightning frequency in region r, continent $c(r)$, and wave w. Lightning exposure is measured as the average monthly strike frequency in 2015 from GHRC (2023).[3] The remaining variables and fixed effects correspond to those in Equation 1.

In the second stage, we estimate the impact of mobile connectivity on labor market outcomes using the instrumented share of the regional population covered by 2G networks. The estimating equation is

$$Y_{rc(r)w} = \alpha + \beta_1 \widehat{2\text{G}}_{rc(r)w} + \text{rain}_r'\beta_w + X_{rw}'\gamma + \mu_r + \mu_{c(r)w} + \epsilon_{rc(r)w}, \tag{3}$$

where $\widehat{2\text{G}}_{rc(r)w}$ is the predicted 2G coverage from the first stage in Equation 2. The coefficient β_1 captures the average effect of an increase in mobile network availability on regional labor market outcomes. All specifications include the same fixed effects and controls as before, and standard errors are clustered at both the regional and country-year levels.

Our identification isolates within-region changes in predicted coverage over time, net of persistent geographic characteristics and continent-wide trends. The coefficients capture the

[3] Spatial patterns of lightning activity have remained highly stable over time, making 2015 an appropriate proxy for long-run exposure. For estimation, we set lightning intensity to zero in the pre-rollout period, mirroring the absence of 2G networks before coverage expansion.

causal effect of mobile network expansion for regions complying with our instrument, where rollout was differentially impeded by lightning-related constraints to signal reliability.

3.3. Assessing Instrument Validity and Exclusion Restrictions

The validity of our instrumental variable requires that lightning exposure influence labor market outcomes only through its effect on mobile network reliability, not through other geographic or climatic channels. Two potential concerns arise. First, lightning frequency could correlate with persistent environmental features, such as elevation, vegetation, or rainfall patterns, that shape agricultural productivity and thus employment composition. Second, lightning activity tends to be more intense in tropical regions, which may correlate with climatic zones characterized by different agricultural potential or stages of economic development.

Following the guidance in Mellon (2024), we address these concerns by using long-run, time-invariant measures rather than contemporaneous weather shocks. Specifically, we employ the mean lightning frequency in 2015 as the instrument and the mean rainfall in 1990 as a control. Lightning data for 2015 are based on modern satellite detection systems that provide the most accurate global coverage available. Although measured after our study period, spatial patterns of lightning activity are highly stable over time, reflecting persistent atmospheric and geographic conditions. Using the 2015 dataset, therefore, offers a reliable proxy for long-run regional exposure while avoiding the measurement error inherent in earlier satellite records. Both variables are time-invariant and measured independently of 2G rollout, ensuring that they capture persistent environmental characteristics rather than short-run fluctuations.

This design limits potential exclusion-restriction violations arising from correlated meteorological or topographical factors that could directly influence labor markets.

Our identification strategy also includes region fixed effects and continent-by-wave fixed effects, which absorb all time-invariant local characteristics and continent-specific trends. A time-placebo exercise that shifts the treatment window to the decade before 2G rollout yields small and statistically insignificant coefficients (Table G10), indicating no systematic pre-trends in labor market outcomes.

In Table B1 we show that the first stage and the 2SLS coefficients are stable when we add rich geographic controls (Column 4) and time variant socioeconomic characteristics (Column 2).

To verify that these effects are not driven by pre-existing trends, we perform a time-placebo test that shifts the treatment window to the decade before the 2G rollout. As shown in Table G10, coefficients are small and statistically insignificant, supporting the validity of the identification strategy.

A limitation of our data is that each country is observed twice, before and after 2G rollout. We interpret this as an advantage for identifying medium-run adjustments rather than short-term fluctuations. To assess potential pre-trends, we conduct a time-placebo test that shifts the

treatment window to the previous decade and find no significant effects (Table G10). Moreover, exposure to 2G coverage varies substantially across countries-ranging from five to twelve years between rollout and the second survey wave-providing additional cross-sectional variation in treatment intensity. These features support the interpretation of our estimates as capturing persistent, post-rollout changes in employment structures.

We present evidence that supports the exclusion restriction: lightning frequency generates plausibly exogenous variation in 2G coverage by affecting signal reliability and infrastructure maintenance, rather than reflecting broader geographic or socioeconomic conditions.

4. Data

This section describes the data sources and sample selection criteria used in the analysis. We combine four primary datasets encompassing socioeconomic, geographic, and climatic information across 13 countries in Africa, Asia, and the Americas. Specifically, we draw on: (i) IPUMS–International for individual labor market outcomes aggregated to regional shares and associated sociodemographic characteristics (Minnesota Population Center, 2020); (ii) GSMA–Collins Bartholomew for geo-referenced 2G network coverage (Bartholomeus, 2025); (iii) NASA's Global Hydrometeorology Resource Center for raster data on lightning frequency (GHRC, 2023); and (iv) PRIO–GRID for environmental and geographic controls (Tollefsen et al., 2012).

4.1. Labor Market Outcomes

We use harmonized microdata from IPUMS–International, which integrates national censuses and large household surveys to ensure comparability of socioeconomic indicators across countries and over time.[4] Individual responses are aggregated to regional shares of key labor market outcomes, creating harmonized region-by-wave panels of comparable employment indicators.[5] These outcomes form the dependent variables in our main empirical specifications.

IPUMS–International provides harmonized variables on four core labor outcomes: (i) labor force participation (*LABFORCE*); (ii) employment status (*EMPSTAT*); (iii) industry of employment (*INDGEN*); and (iv) class of worker (*CLASSWK*). Additional information on age, gender, and education is used as control variables in selected specifications. To focus on the active workforce, we restrict the sample to individuals aged 25–65.

We classify employment by sector following the three-sector taxonomy proposed by Duernecker and Herrendorf (2022), grouping activities into primary (agriculture and mining), secondary (manufacturing and construction), and tertiary (services) sectors.[6] For employment

[4] For most countries, census or survey waves are available roughly every ten years (see bottom panel of Figure 1).

[5] Regions are the smallest consistent administrative units below the state level. Boundaries follow GADM Version 4.1, reconciled with IPUMS–International's harmonized subnational definitions, which remain constant across census years.

[6] The detailed mapping of industries into sectors is reported in Table G1.

type, we distinguish among wage, self-, and unpaid work based on respondents' reported employment arrangements.

From these harmonized variables, we construct eight main outcomes: labor force participation, total employment, and the shares of wage, self-, and unpaid employment, together with employment shares in agriculture, manufacturing, and services. In the mechanism analysis, we further exploit the detailed industry and employment classifications to examine the micro-level shifts underlying our aggregate results

4.2. Mobile Coverage Infrastructure

We use geo-referenced data on 2G (GSM) mobile network coverage compiled by the GSM Association (GSMA) in collaboration with Collins Bartholomew, a digital map provider that aggregates coverage reports from multiple mobile network operators. The dataset provides annual information beginning in 1999 on the presence of 2G networks at a fine geographic resolution that varies by country, from approximately 1 to 23 square kilometers.[7]

The GSMA-Collins Bartholomew dataset has become a standard source for studying the economic and social effects of mobile network expansion, including analyses of mobile internet diffusion and labor market outcomes in developing economies (e.g., Guriev et al., 2021; Mensah, 2023; Caldarola et al., 2022; Bahia et al., 2021, 2024). Following Guriev et al. (2021) and Manacorda and Tesei (2020), we construct a population-weighted regional coverage measure by overlaying GSM maps with gridded population data from NASA's Socioeconomic Data and Applications Center (CIESIN-Columbia University, 2018), computing the share of each region's population living within covered areas (see Appendix Appendix A.1 for details).

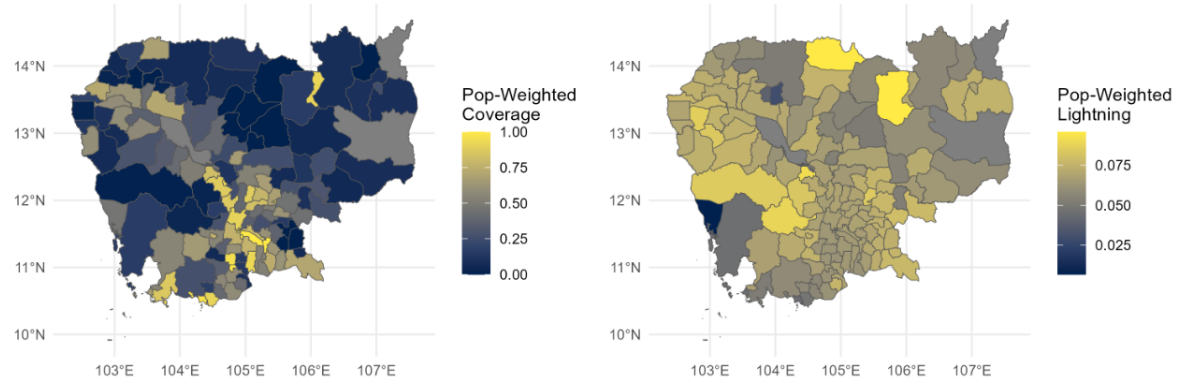
4.3. Lightning Strike Data

We construct the instrumental variable using data from NASA's Global Hydrometeorology Resource Center (GHRC), which provides a global 0.5-degree raster of average lightning frequency for 2015[8]. Spatial patterns of lightning activity are highly stable over time, making this dataset a suitable proxy for long-run regional exposure. For each administrative region, we compute the population-weighted mean lightning frequency using the same procedure applied to mobile coverage (**??**). Figure 2 illustrates the spatial relationship for Cambodia: the right panel shows lightning frequency by sub-national division, while the left shows 2G mobile coverage in 2000. Regions with more frequent strikes exhibit systematically lower coverage, providing the exogenous variation exploited in our instrumental-variable design.

[7] Because of a change in the data collection protocol, information for 2005 and 2010 is not directly observed. To maintain a balanced time series, we linearly interpolate coverage for these years using the nearest available observations (2004 and 2006 for 2005; 2009 and 2011 for 2010). This procedure follows prior work in the connectivity literature (Guriev et al., 2021) and preserves consistency in coverage measurement over time.

[8] A grid cell corresponds to approximately 55 km × 55 km at the equator.

Figure 2: Cambodia: 2G Coverage and Lightning Strike Frequency



Notes: The left panel shows the share of the population covered by 2G networks in 2000. The right panel reports the population-weighted frequency of lightning strikes. Darker areas indicate higher values. The negative spatial correlation between the two variables provides the basis for our instrumental-variable design.

4.4. Working Panel

Our analysis is based on a balanced panel of 2,040 administrative regions across 13 countries in Africa, Asia, and Latin America, each observed in two survey waves separated by a median of eleven years. This design enables within-region comparisons of labor market dynamics before and after the rollout of 2G coverage.

The 13-country sample is defined in three steps. We begin with all IPUMS–International countries classified by the World Bank as low- or middle-income in 2000, retain only those with at least one census or large household survey before nationwide 2G rollout, and finally require that at least five percent of the national population had 2G coverage by the first post-rollout survey. These criteria ensure credible pre- and post-treatment variation while maintaining cross-country comparability.

Table G2 reports the timing of 2G and 3G rollout for all countries in the sample. The second survey wave for each country is selected to capture labor market conditions after the introduction of 2G networks but before the diffusion of 3G technology. The only exception is Guinea, where the second wave occurred in 2014, coinciding with the introduction of 3G.[9] This timing ensures that our estimates reflect the effects of basic mobile connectivity, uncontaminated by subsequent internet-enabled technologies.

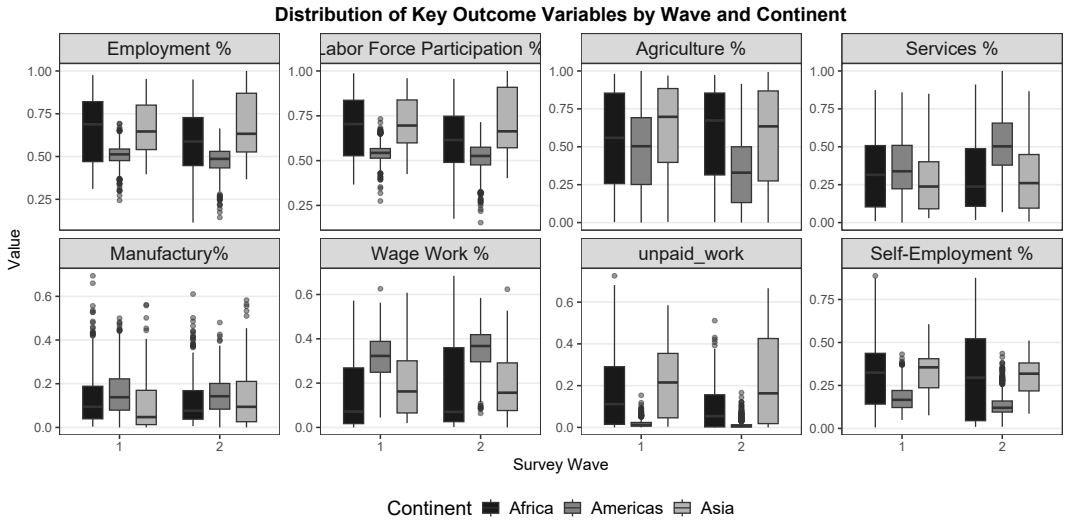
Our analysis focuses on eight key labor market outcomes capturing the size and composition of the active labor force, its sectoral distribution, and the type of employment. Because survey coverage varies across countries and waves, we construct three analytical samples matched

[9] In Guinea, 3G coverage remained minimal in 2014, the year of the second wave (see **??**).

to outcome availability. The full sample, used for labor force participation, overall employment, and educational outcomes, includes 13 countries and 4,080 region-wave observations. The sectoral sample excludes Mozambique, Guinea, and Bangladesh, which lack detailed industry information (10 countries, 2,988 observations). The employment-type sample excludes Mozambique, which does not report employment categories (12 countries, 3,794 observations).

Before turning to the empirical strategy, Figure 3 summarizes the distribution of the main labor market outcomes across continents and waves. The figure shows marked heterogeneity in baseline employment shares, particularly across agriculture, manufacturing, and services.

Figure 3: Density distributions: Outcomes



Notes: Showing the boxplot distribution of the IPUMS-International Labor market Outcomes regional shares in our sample across appearances.

5. Conceptual Framework: Information, Search, and Labor Reallocation

This section outlines the conceptual framework linking the diffusion of basic mobile connectivity to changes in employment structure. Our goal is not to develop a formal model, but to highlight the key mechanisms, grounded in theories of information frictions, search and matching, and structural transformation, that guide our empirical analysis.

The diffusion of basic mobile connectivity can influence labor markets through several complementary channels. At its core, the arrival of second-generation (2G) networks substantially reduced the cost of communication and information exchange across space. Lower information frictions improve both job search and production coordination: workers gain access to information about vacancies, wages, and migration opportunities, while firms can reach a broader labor pool, organize supply chains more efficiently, and adjust production to local demand conditions. These mechanisms are particularly relevant in developing economies, where labor markets are geographically fragmented and formal job search channels are limited (Aker and Mbiti, 2010; Jensen, 2007; Manacorda and Tesei, 2020).

In a search-and-matching framework (e.g., Bryan and Morten, 2019), a reduction in information frictions raises matching efficiency between workers and firms, increasing the share of wage employment relative to self-employment. At the same time, improved communication facilitates the diffusion of price and demand information in goods markets, promoting specialization and trade (Donaldson, 2018; Aker and Mbiti, 2010). When combined, these channels foster a reallocation of labor toward more formal and higher-productivity activities, consistent with the early stages of structural transformation (Duernecker and Herrendorf, 2022). Because 2G networks provided voice and text connectivity but not internet access, these effects operate primarily through enhanced coordination, information flows, and mobility within existing productive sectors rather than through the creation of new digital occupations.

This framework yields three empirical predictions. First, the expansion of 2G coverage should increase overall labor-force participation and wage employment as job matching improves. Second, regions more specialized in tradable activities should experience stronger gains, reflecting higher returns to coordination and market access. Third, educational attainment should rise as households respond to improved returns to formal and wage-based work. These predictions guide the heterogeneity analyses presented in Section 7.

6. Results

We estimate the effect of 2G mobile network coverage on labor market outcomes in thirteen countries across Africa, Asia, and the Americas.[10] Our endogenous treatment variable is the share of the regional population with active 2G coverage. To address potential endogeneity, we instrument this measure with the share of the population residing in areas historically exposed to high-intensity lightning strikes, a source of variation plausibly unrelated to unobserved determinants of labor market outcomes. Under the standard IV assumptions, the resulting estimates identify Local Average Treatment Effects (LATE) for regions whose 2G coverage is affected by lightning strike exposure, based on 2,040 regional units in our sample.

6.1. First Stage

We begin by estimating the first-stage regression that links our instrument, regional exposure to high-intensity lightning strikes, to the endogenous treatment variable, the share of the population with active 2G coverage. Lightning strikes are a strong and precisely estimated predictor of 2G availability, confirming the instrument's relevance.

As shown in Table 1, the coefficient on lightning strikes is negative and significant across all specifications. In the baseline model (Column 1), the estimate is −2.65; adding baseline (1990) rainfall controls (Column 2) yields −2.61, and further adding time-invariant socio-demographics and resource controls (Column 3, our preferred specification) produces −2.45.

[10] Africa: Benin, Egypt, Guinea, Mozambique, Uganda; Asia: Bangladesh, Cambodia, Malaysia; Americas: Chile, Colombia, El Salvador, Paraguay, Venezuela.

Kleibergen–Paap F-statistics are well above 10 in all cases, alleviating weak-instrument concerns.[11]

Table 1: First Stage

Mobile Coverage	(1)	(2)	(3)
Lightning Strikes	−2.650*	−2.617*	−2.450**
	(1.079)	(1.050)	(0.759)
# Obs.	4080	4080	4080
# Countries	13	13	13
R^2	0.74	0.74	0.75
Region FE	Yes	Yes	Yes
Continent x Wave FE	Yes	Yes	Yes
Rain Controls	No	Yes	Yes
Further Controls	No	No	Yes
Mean Dep. Var.	0.26	0.26	0.26

Notes: Lightning strike intensity from NASA Earthdata is population-weighted using NASA SEDAC gridded population data and normalized between 0 and 1. Model (2) controls for baseline (1990) rainfall interacted with the wave dummy. Model (3) adds time-invariant socio-demographics (age, age squared, gender) and time-invariant resource controls (presence of diamond deposits, presence of gold veins, and surface area of gold veins), each interacted with the appearance dummy. Standard errors are two-way clustered at the regional and country-year levels. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

We next probe the stability of the first stage by relaxing modeling assumptions (Appendix B). We vary the fixed effects, switch from time-invariant to time-varying rainfall and socio-demographics (Table B1, Column 1 and Column 2) , and add baseline controls for oil resources, drought probability, herb land share, and terrain roughness (Table B1, Column 4). Across these changes, the coefficient on lightning strikes stays within 8 percent of the preferred estimate and remains significant.

We also test robustness to alternative samples. Restricting the regression to the subsamples used for the employment type (Table B2, Column 1) and employment sector (Table B2, Column 2) analyses yields nearly identical first-stage coefficients. These samples are smaller because only 9 of 13 countries report sector data, and 12 of 13 report employment type in IPUMS International surveys.

6.2. Main Labor Market Effects

We begin by examining labor force participation and overall employment (Table 2). Instrumented estimates indicate that a one-percentage-point increase in 2G coverage raises participation by 0.389 points and employment by 0.381 points in the full sample. With an average 0.52-point increase in coverage between survey waves, this corresponds to gains of roughly 0.20 percentage points in both participation and employment, about one-third of their baseline rates. In the labor-active sample, where mean employment is already 94%, the effect is

[11] F-statistics are reported with the main 2SLS results.

small and imprecise, suggesting that expanded coverage raises overall employment mainly by drawing new entrants into the labor force rather than increasing employment among those already active.

Table 2: 2SLS: Regional LFP and Employment Share

	LFP (1)	Emp % (2)	Emp % Active Sample (3)
Mobile Coverage	0.389**	0.381**	0.053
	(0.132)	(0.131)	(0.058)
# Obs.	4080	4080	4080
# Countries	13	13	13
Region FE	Yes	Yes	Yes
Continent x Wave FE	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Mean Dep. Var.	0.61	0.59	0.94
Wald F-stat	10.43	10.43	10.43

Notes: This table presents the 2SLS results on labor force participation and employment shares. Columns (1) and (2) report results for LFP and employment shares in the full sample, while Column (3) reports results for employment shares in the active sample. In all specifications, the instrument is a continuous measure of the share of the population affected by lightning strikes. And we are controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

For comparison, the naïve OLS estimates in Table G3 are close to zero, while the reduced-form results in Table G4 show that lightning strikes, our instrument, reduce both participation and employment, and also reduce 2G coverage in the first stage (Table 1). The alignment between the RF and IV patterns supports the interpretation of a meaningful causal effect operating through mobile coverage.

6.3. Compositional Effects

Turning to employment composition, Table 3 shows that in the full employment type sample higher coverage leaves self-employment essentially unchanged (0.001) but raises the shares of wage work (0.136) and unpaid work (0.173), both statistically significant [12] . Relative to their means of 0.25 and 0.09, these correspond to large proportional gains of roughly 54 percent and 192 percent. Given the average increase in 2G coverage of 0.52 between survey waves, the estimates imply that roll-out was associated with an increase of about 7 percentage points in wage work and 9 percentage points in unpaid work.

[12] 12 countries, with Mozambique not reporting employment type information. We report in Table B2 that the first stage holds for this subsample.

In the labor-active and employed samples (Table G7 and Table G8), the coefficients retain their signs, but are smaller and imprecisely estimated, indicating that the main compositional shifts occur when new entrants choose wage or unpaid work instead of self-employment.

Table 3: 2SLS: Employment Type

	Self Emp (1)	Wage Work (2)	Unpaid Work (3)
Mobile Coverage	0.001	0.136***	0.173*
c	(0.081)	(0.031)	(0.064)
Mean Dep. Var.	0.24	0.25	0.09
Obs.	3794	3794	3794
# Countries	12	12	12
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes
Wald F-stat	16.00	16.00	16.00

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent × appearance level on the employment types (self-employment, wage work, unpaid work, and other employment) shares as outcomes. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Sectoral results tell a complementary story. In the ten countries with sectoral data [13], Table 4 shows that coverage increases the agricultural share by about 0.25 points (over 100% of its mean), leaves manufacturing largely unchanged, and raises the services share by 0.164 points, though the latter is imprecisely estimated. In the labor-active and employed samples (Table G9), the agricultural share continues to rise, manufacturing remains essentially unchanged, and the residual adjustment comes from a relative decline in services. This pattern reinforces the view that coverage expansion does not reallocate labor out of agriculture but instead draws additional workers into it, with services absorbing the offset. The consistency of the agricultural gains across samples suggests that basic mobile connectivity strengthens, rather than displaces, agricultural work, likely by improving access to market information, input supply chains, and price signals (Mbarika et al., 2004; Gitta and Ikoja-Odongo, 2003; George et al., 2011).

Overall, the estimates from Table 2, Table 3, and Table 4 reveal a consistent pattern across labor outcomes. Expanded 2G coverage is associated with higher participation, notable shifts in the composition of employment toward wage and unpaid work, and persistent gains in agricultural employment. These patterns are largely absent in OLS estimates (Table G3) but emerge clearly in the IV results, where the reduced-form and first-stage relationships reinforce

[13] Mozambique, Bangladesh, and Guinea are not reporting employment sector information

Table 4: 2SLS: Employment Sector

	Agriculture (1)	Manufactury (2)	Services (3)
Mobile Coverage	0.246*	0.012	0.164
	(0.106)	(0.021)	(0.108)
# Obs.	2988	2988	2988
# Countries	9	9	9
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes
Mean Dep. Var.	0.23	0.08	0.20
Wald F-stat	8.12	8.12	8.12

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional and continent times appearance level on the employment sectors (agriculture, manufacturing, and services) shares as outcomes. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

the plausibility of a causal interpretation. The next section examines how these effects compare to prior studies and explores potential mechanisms driving the observed reallocation.

Effect size. The results point to a consistent story: expanding 2G mobile coverage increases labor force participation and shifts employment toward agriculture and formal wage work, with corresponding declines in self-employment and, in some cases, services. These effects are sizable, participation gains are on the order of one-third of baseline rates, while the agricultural share more than doubles in relative terms, and remains stable across specifications and samples. The patterns suggest that even the most basic mobile infrastructure can meaningfully reduce information frictions, draw new entrants into the labor force, and facilitate a reallocation toward sectors where simple, timely communication can enhance productivity. While increases are mainly in agriculture, they occur partly in formal wage work rather than self-employment.

These findings complement and contrast with prior work on more advanced mobile technologies. Caldarola et al. (2022) show that the roll-out of 3G in Rwanda spurred employment growth primarily in services, whereas our estimates point to stronger gains in agriculture and wage work. This divergence likely reflects differences in technological capabilities: 2G networks provide voice and SMS but not broadband data, favoring sectors that rely on basic communication rather than those requiring rich data flows. More broadly, our results are consistent with Hjort and Tian (2025), who document productivity gains from broadband internet in African firms, and with Chiplunkar and Goldberg (2022), who find that enhanced digital connectivity in India reshaped employment patterns toward higher-skill services. This evidence highlights that the nature of technological infrastructure conditions which sectors benefit most from connectivity, with 2G networks supporting more traditional activities while

broadband-intensive technologies shift employment toward services. In agriculture, our results are consistent with Jensen (2007), who show how mobile phones reduced information asymmetries in fish markets, enabling producers to respond more efficiently to price signals and market conditions. The shift toward wage employment aligns with studies linking connectivity to labor market formalization by lowering job search costs and improving access to information about formal opportunities.

The weaker or negative effects on services may have two explanations. First, 2G's limited functionality may be insufficient to substantially support the information-intensive activities common in many service subsectors. Second, the aggregate effect may mask heterogeneity, with positive gains in some service activities offset by declines in others. We explore this possibility in Section 7.4, which disaggregates service employment into finer categories.

6.4. Placebo and Robustness

Finally, we assess the credibility of our identification strategy. A placebo exercise (Section Appendix C.1) exploits the six countries in our dataset with an additional earlier wave in IPUMS-International. We construct a three-wave panel, shift the "treatment" to the early 1990s (well before actual rollout), and use the 1980s as the baseline. The placebo estimates, reported in Figure C1, are small and statistically insignificant across all outcomes, while the reference estimates remain large and precise. This rules out differential pre-trends as the main driver of our results.

Robustness checks further support our conclusions. Using a control function approach (Table C6, Table C5, Table C4) yields coefficients similar in magnitude and significance to our main IV results, indicating they are not sensitive to weak-instrument concerns.

Alternative fixed effects specifications (Table C3, Table C1, Table C2) and alternative control combinations that incorporate time-varying rainfall, time-varying socio-demographics, and additional geographic controls (Table G12; Table G13, Table G14) yield estimates that are statistically and economically similar to our preferred results. The stability of the coefficients across these diverse checks reinforces the credibility of the identification strategy and supports interpreting the documented effects as genuine responses to improved mobile coverage.

We also investigate potential mechanisms. In Section 7.1, we test whether the initial 2G rollout improved educational outcomes, consistent with better access to information on the returns to schooling. In Section 7.2, we examine whether effects differ between regions specialized in tradable goods and services and those dominated by non-tradable activities. This distinction sheds light on whether the observed shifts are driven primarily by improved market integration or by local reallocation effects.

7. Mechanisms and Heterogeneity

7.1. Education Mechanism

Table 5 examines the effect of mobile coverage on the highest level of education completed. The outcomes distinguish individuals with less than primary schooling, those who completed primary school, those who completed secondary school, and those who completed university. The results show a clear movement up the educational ladder. Coverage reduces the probability of stopping at primary school by 0.15 points, relative to a mean of 0.30, and raises the probability of completing secondary school by 0.14 points, more than doubling its baseline rate of 0.13. The small and imprecise decline in the share with less than primary schooling suggests limited effects at the very bottom of the distribution, while university completion remains unchanged, consistent with its low mean of only two percent. Taken together, the estimates indicate that mobile connectivity fostered progression beyond primary school and shifted the distribution of attainment toward secondary education, without yet extending to the university level. Evidence from other contexts points to similar mechanisms. In the Peruvian setting, Lakdawala et al. (2023) show that expanding internet access in public primary schools improved student learning, suggesting that better connectivity may reinforce both educational achievement during schooling and the likelihood of continuing to higher levels of attainment.

Table 5: 2SLS: Education Outcomes

	Less than Primary (1)	Primary (2)	Secondary (3)	University (4)
Mobile Coverage	−0.042	−0.151*	0.140**	0.003
	(0.071)	(0.055)	(0.047)	(0.031)
# Obs.	4080	4080	4080	4080
# Countries	13	13	13	13
Region FE	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.54	0.30	0.13	0.02
Wald F-stat	10.43	10.43	10.43	10.43

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent × appearance level on a categorical education outcome. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

7.2. Production-Orientation Mechanism

We next explore whether the impact of mobile coverage depends on the production orientation of regional economies. The distinction between production- and consumption-driven urbanization, emphasized by Gollin et al. (2016) and Jedwab et al. (2025), suggests that infrastructure shocks may yield heterogeneous effects depending on the underlying employment struc-

ture. Regions with a higher baseline share of employment in tradable sectors such as manufacturing, mining, utilities, business and financial services, and transport, production-oriented regions, may be better positioned to translate connectivity gains into new employment opportunities. By contrast, regions where employment is concentrated in non-tradable activities such as construction, trade, education, health, and public administration, consumption-oriented regions, may experience more muted responses.

Table 6: 2SLS: Production Orientation

	Emp (1)	LFP (2)	Wage Work (3)	Unpaid Work (4)	Self Emp (5)
Mobile Coverage	0.303	0.336	0.204*	0.038	0.070
	(0.186)	(0.197)	(0.074)	(0.034)	(0.138)
Mobile Coverage × Share Trade	0.110+	0.127+	0.089**	0.023	0.007
	(0.063)	(0.069)	(0.025)	(0.016)	(0.039)
# Obs.	3274	3274	2988	2988	2988
# Countries	12	12	9	9	9
Mean dep. var	0.57	0.61	0.25	0.09	0.24
Wald F-stat	28.82	28.82	33.87	33.87	33.87
Region FE	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes

Notes This table presents the results of the 2SLS regressions with the interaction between both the instrument and the mobile coverage with the production orientation share of each region. This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent × appearance level on a categorical education outcome. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table 6 reports the heterogeneous 2SLS estimates from specifications interacting both mobile coverage and the instrument with the baseline share of employment in tradable sectors. The results indicate that mobile coverage significantly raises wage work in more production-oriented regions. The interaction coefficient is positive and statistically significant for wage employment (Column 3), implying that an increase in the tradable employment share amplifies the employment gains from mobile coverage. Similar but less precise patterns emerge for overall employment and labor force participation (Columns 1–2), while the effects on unpaid work and self-employment (Columns 4–5) remain small and statistically insignificant. Taken together, these findings suggest that the expansion of mobile networks disproportionately benefits regions specialized in tradable activities, consistent with the idea that production-oriented economies are more capable of leveraging new technologies for formal job creation.

Summary statistics on production orientation across regions are presented in Table F1, and the strength of the instrument in this heterogeneous setting is confirmed by the first-stage regressions in Table F2.

7.3. Within-Sector Splits

We next examine whether mobile coverage affects the composition of employment within sectors by distinguishing between self-employment, wage work, and unpaid work. The estimates in Table G21 reveal sharp heterogeneity in these margins. In agriculture, mobile coverage increases wage employment by 0.33 points on a base of 0.28 (a 117 percent gain), while reducing self-employment by 0.23 points on a base of 0.47 (a 48 percent decline). This pattern suggests a reallocation of labor away from own-account farming toward wage contracts, consistent with reduced search frictions in seasonal and casual hiring. In manufacturing, the main effect arises in unpaid work, which rises by 0.29 points relative to a mean of 0.10 (a 290 percent increase), while wage employment remains unchanged. This points to an expansion of family-based production rather than formal sector jobs. Services exhibit a more mixed response: self-employment rises modestly, unpaid work increases by 0.45 points on a mean of 0.23 (a 196 percent gain), and wage work falls by 0.28 points on a mean of 0.53 (a 53 percent decline). Looking at these heterogeneity in their complex they indicate that mobile technology not only shifts labor across sectors but also restructures employment relations within sectors, with sizable gains in agricultural wage jobs offset by increases in informal and unpaid work elsewhere.

7.4. Granual Employment Outcomes

To unpack the broad shifts identified in our analysis, we exploit the fine-grained coding of employment sectors and job types to pinpoint which subsectors were most affected by the rollout of 2G coverage.

The sectoral breakdown in Table G15, Table G16, and Table G17 indicates that the aggregate patterns are driven by specific subsectors. Within manufacturing, construction employment increases by about 3.0 percentage points (Column 3 of Table G16), while the manufacturing component itself falls slightly, leaving the overall effect close to zero. In services, the strongest gains occur in retail, where the share rises by 0.14 pp, and in business and health services, with increases of 0.06 pp and 0.03 pp, respectively (Columns 3, 9, and 11 of Table G17). Other service subsectors show no significant response.

The detailed employment type results in Table G19, Table G20, and Table G18 highlight parallel reallocations. In the unpaid segment, apprenticeships rise sharply by 0.19 pp while family unpaid work falls by 0.01 pp, suggesting that additional unpaid activity reflects new entrants training rather than incumbents reverting to family work. In self-employment, new self-employment increases by 0.007 pp and cooperatives by 0.001 pp, offset by declines in own-account and employer categories (-0.015 pp and -0.007 pp). Wage work records the clearest gains: total wage employment increases by 0.14 pp (Panel A of Table G18), with day-labour and permanent positions both expanding. White- and blue-collar employment also rise (0.03 pp and 0.08 pp), while Panel B shows a small reallocation away from private firms (-0.04 pp) toward public and parastatal jobs.

7.5. *Population Changes mechanism*

Table Table 7 presents the 2SLS estimates for logged population outcomes. A one–unit increase in coverage lowers the number of residents by about 14 percent relative to the mean. The effect is more pronounced among younger cohorts, with a decline of roughly 17 percent in the under-25 population compared to about 13 percent for older residents. Similar reductions are observed for individuals born locally, indicating that improved connectivity facilitates out-migration rather than simply deterring in-migration.

Table 7: 2SLS: Population Changes

	N. Live here (1)	N. Live here Over 25 (2)	N. Live here U25 (3)	N. Live and Born here (4)
Mobile Coverage	−1.078*	−1.006*	−1.293**	−1.291*
	(0.394)	(0.395)	(0.438)	(0.521)
# Obs.	4080	4080	4080	3564
# Countries	13	13	13	13
Region FE	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes	Yes
Mean Dep. Var.	7750.60	4997.40	2753.19	4960.48
Wald F-stat	10.43	10.43	10.43	9.00

Notes This table presents the results of the 2SLS regressions on population size changes break down but age (under and above 25) and nativity. This table presents the results with fixed effects at the regional level and continent × appearance level on a categorical education outcome. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

7.6. *Gender Heterogeneities*

Table 8 presents estimates from specifications at the gender–region–wave level, covering between 7,234 and 8,160 observations across 9 to 13 countries depending on the outcome. All regressions include region fixed effects interacted with gender and continent–wave fixed effects. The first stage in Table G22 confirms that the instruments are relevant for both mobile coverage and its interaction with female status.

The coefficients show marked differences between men and women in the labor market response to mobile coverage. For agriculture, mobile coverage reduces participation by 0.41 among men, which is large relative to the mean of 0.29, but this effect is almost exactly offset for women by the positive and significant interaction of 0.41. The pattern implies no net effect for women, while men are crowded out of agricultural work. In services and wage employment, the female interactions are positive and significant, amounting to increases of 0.11 and 0.16 relative to mean baseline probabilities of 0.18 and 0.24. These represent sizable shifts into services and wage work among women, whereas the corresponding estimates for men are close to zero. Labor force participation and overall employment also rise for women relative to men, with coefficients around 0.21, consistent with the sectoral reallocations. By contrast, the interactions for manufacturing, self-employment, and unpaid activities are small and imprecisely estimated, suggesting no systematic gender differences in these categories.

Table 8: 2SLS: Gender Heterogeneities

	LFP (1)	Emp (2)	Agri (3)	Manuf (4)	Serv (5)	Unpaid (6)	Self Emp (7)	Wage (8)
Mobile Coverage	0.019	0.002	−0.411+	−0.037	0.024	0.377*	−0.226	−0.080
	(0.264)	(0.266)	(0.199)	(0.033)	(0.141)	(0.168)	(0.140)	(0.101)
Mobile Coverage x Female	0.208	0.221	0.411**	0.041	[draw,circle]0.105**	−0.135	0.129	[draw,circle]0.161*
	(0.142)	(0.141)	(0.108)	(0.030)	(0.029)	(0.088)	(0.109)	(0.061)
# Obs.	8160	8160	7234	7234	7234	7588	7588	7588
# Countries	13	13	9	9	9	12	12	12
Region FE × Female	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.62	0.59	0.29	0.07	0.18	0.10	0.26	0.24
F-stat (2G)	4.37	4.37	3.76	3.76	3.76	5.51	5.51	5.51
F-stat (2G × Female)	85.78	85.78	47.05	47.05	47.05	89.98	89.98	89.98

Notes This table presents the results of the 2SLS regressions of mobile coverage on employment outcomes run within a sample of gender-wave-region cells. This table presents the results with fixed effects at the regional level and continent × appearance level on a categorical education outcome. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

7.7. Age Heterogeneities

Table 9 reports results from specifications estimated at the age–region–wave level, where the sample is split at the median age of 32 years. The first stage in Table G23 confirms the strength of the instrument both for mobile coverage and its interaction with the older group indicator.

The estimates indicate that younger cohorts drive most of the labor market response to mobile coverage. For overall labor force participation and employment, coverage raises outcomes by 0.28 and 0.27, respectively, relative to means of 0.60 and 0.56. The interaction with older status is positive but modest in magnitude (0.06–0.08), implying that the bulk of the gains accrue to younger individuals. Sectoral results reinforce this pattern. In agriculture, the main effect of 0.18 (relative to a mean of 0.28) is almost entirely confined to younger workers, as the interaction with older status is negative and not statistically significant. Similarly, wage employment rises by 0.12, or about half of its mean baseline probability, with little additional effect for older individuals. By contrast, older groups experience somewhat larger improvements in unpaid activities, though these estimates are imprecise. For manufacturing and self-employment, the coefficients are small and indistinguishable from zero across age groups.

Overall, the evidence points to a sharper reallocation of younger workers into agriculture and wage employment, while older workers exhibit weaker and less systematic adjustments.

7.8. Education Heterogeneities

Table 10 presents results at the education–region–wave level, where the sample is split at completion of secondary schooling. The first stage in Table G24 confirms instrument relevance for both mobile coverage and its interaction with education status.

The results show that the less educated account for most of the employment gains from mobile coverage. Overall employment increases by 0.44 and wage work by 0.45, relative to means of

Table 9: 2SLS: Age Heterogeneities

	LFP (1)	Emp (2)	Agri (3)	Manuf (4)	Serv (5)	Unpaid (6)	Self (7)	Wage (8)
Mobile Coverage	0.283*	0.267*	0.184*	0.002	0.109	0.098+	0.012	0.117*
	(0.121)	(0.126)	(0.067)	(0.021)	(0.089)	(0.050)	(0.081)	(0.044)
Mobile Coverage ×*Older*	0.061**	0.082**	−0.026	0.002	0.029	0.045	−0.037	0.048
	(0.022)	(0.027)	(0.021)	(0.006)	(0.018)	(0.038)	(0.023)	(0.037)
# Obs.	8160	8160	7234	7234	7234	7588	7588	7588
# Countries	13	13	13	13	13	13	13	13
Region × Older FE	No	No	No	No	No	No	No	No
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.60	0.56	0.28	0.07	0.16	0.11	0.21	0.23
F-stat (2G)	6.15	6.15	4.83	4.83	4.83	16.25	16.25	16.25
F-stat (2G × Older)	80.79	80.79	60.48	60.48	60.48	104.24	104.24	104.24

Notes This table presents the results of the 2SLS regressions of mobile coverage on employment outcomes run within a sample of age split-wave-region cells, where the split is done at the median age that is 32 years old in the sample. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

0.59 and 0.28. Services also rise strongly, with an effect of 0.51 against a mean of 0.21. By contrast, effects on agriculture, manufacturing, unpaid work, and self-employment are small and imprecise. The interaction with education is close to zero throughout, indicating that additional schooling does not amplify the effects of coverage.

Table 10: 2SLS: Education Heterogeneities

	LFP (1)	Emp (2)	Agri (3)	Manuf (4)	Serv (5)	Unpaid Work (6)	Self Emp (7)	Wage Work (8)
Mobile Coverage	0.285	0.441*	0.073	0.049	0.514*	0.013	−0.067	0.450**
	(0.169)	(0.160)	(0.067)	(0.030)	(0.203)	(0.048)	(0.099)	(0.123)
Mobile Coverage × Literacy	−0.013	−0.104	0.131*	−0.025**	−0.292*	0.128	0.041	−0.279+
	(0.070)	(0.070)	(0.049)	(0.009)	(0.113)	(0.080)	(0.025)	(0.138)
#	8142	8142	7217	7217	7217	7572	7571	7571
# Countries	13	13	13	13	13	13	13	13
Region FE	No	No	No	No	No	No	No	No
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.62	0.59	0.26	0.07	0.21	0.08	0.23	0.28
F-stat	3.97	3.97	3.66	3.66	3.66	5.51	5.54	5.54
F-stat (2G × Literacy)	49.35	49.35	29.70	29.70	29.70	50.99	50.88	50.88

Notes This table presents the results of the 2SLS regressions of mobile coverage on employment outcomes run within a sample of education split-wave-region cells, where the split is done at the completion of secondary education. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

In sum, basic connectivity expands access to wage and service jobs primarily among workers without secondary education, while those with more schooling show limited additional responsiveness.

8. Conclusion

This paper estimates the effects of basic mobile connectivity on labor market outcomes in developing economies. Exploiting exogenous variation in 2G rollout generated by lightning strikes, we find that expanded coverage substantially increases labor force participation and employment. A 50 percentage point increase in regional coverage raises participation by around 0.20 percentage points and employment by 0.19 percentage points, roughly one-third of their baseline rates. The instrument is strong, the reduced form aligns with the first stage, and naïve OLS estimates are close to zero, supporting a causal interpretation.

The distributional effects are large. Higher coverage reallocates labor from self-employment toward wage work and unpaid activities. Wage work rises by more than half relative to its mean, while unpaid work almost triples. Sectoral estimates point to durable gains in agriculture, modest and imprecise changes in services, and little effect on manufacturing. Within-sector results show that agriculture absorbs new workers mainly through wage contracts, manufacturing through additional family work, and services through unpaid or informal positions. Granular breakdowns confirm these reallocations: apprenticeships increase sharply while family unpaid work declines, new self-employment and cooperatives grow modestly while own-account and employer categories contract, and wage jobs expand through both day labor and permanent positions, with shifts away from private and domestic work toward public and parastatal employment.

Two mechanisms help explain these patterns. First, education outcomes adjust, with coverage reducing the share of individuals with only primary schooling and raising secondary attainment, particularly among younger cohorts. Second, effects vary by production orientation: regions with a larger share of tradable employment see stronger gains in wage work, consistent with greater capacity to translate connectivity into formal jobs. Heterogeneity analyses show that effects are largest for workers with primary and secondary schooling and for the young, with modest gender differences, and they take the form of shifts from self employment into wage and unpaid work, especially in agriculture, with smaller and imprecise changes in services and limited effects in manufacturing.

The evidence highlights that the labor market impact of digital infrastructure depends on the technology deployed. While 3G and broadband expansions in other contexts primarily boosted service employment, the rollout of 2G increased participation and shifted labor toward agriculture, apprenticeships, and wage work. Even the most basic networks thus altered employment structures in low-income settings, not by fostering advanced services, but by reducing information frictions in traditional sectors and formalizing segments of rural labor markets.

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Online Appendix

Connection Leapfrog: the impact of 2G roll-out on employment outcomes for first-time connected regions

by *Marta Bernardi* and *Valentin Lindlacher*

Appendix A. Data

Appendix A.1. Population- Weightning

This section outlines the methodology applied to incorporate population weighting into the empirical analysis, detailing the procedures employed to generate the endogenous and instrument variables in the main specifications.

The 2G mobile coverage share, defined as the proportion of *GEOLEVEL2* (subnational unit) covered by 2G connection, is subjected to population weighting using a 0.1-degree population density raster dataset for the year 2000 (https://neo.gsfc.nasa.gov/view.php?datasetId=SEDAC_POP), sourced from the NASA-SEDAC website. Let P_{ij} denote the population density in grid cell j and C_{ij} represent the coverage of 2G technology in year $i$in the same cell. The population-weighted coverage $\hat{C}_{ij}$ is computed as follows:

$$\hat{C}_{ij} = \frac{\sum_{i,j} P_{ij} \cdot C_{ij}}{\sum_{i,j} P_{ij}}$$

To perform the spatial extraction of the population density within the year-specific coverage shapes is applied an adjustment algorithm that iterates over each grid cell intersecting with the coverage shapefile to determine the share of the cell that is comprehended within the boundaries of the shapefile. Then, the covered population is divided by the total population density within the subnational unit to obtain a normalized share of population-weighted coverage for each year in each subnational unit.

The instrumental variable, lightning strikes, is also subjected to population weighting using data from the same source as the 2G mobile coverage weighting but at a larger resolution (0.5 degrees) to align with the resolution of the instrument's raw data. Let S_{ij} denote the average strikes and P_{ij} represent the population density in grid cell (i, j). The population-weighted strikes $\hat{S}_{ij}$ are computed as:

$$\hat{S}_{ij} = \frac{\sum_{i,j} P_{ij} \cdot S_{ij}}{\sum_{i,j} P_{ij}}$$

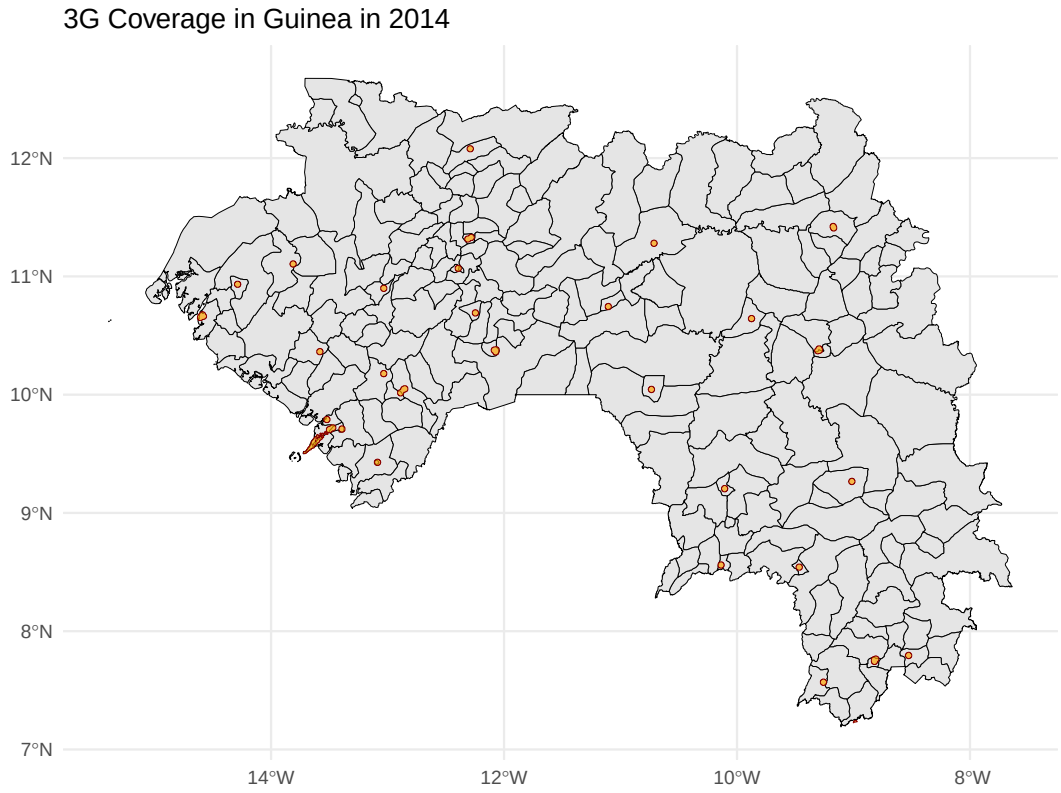
The computation involves overlaying the population and lightning data rasters and performing a cell-wise product, followed by the intersection of the resulting raster with the shapefile of the sub-national administrative units. Subsequently, the sum of the product among the cells within the *GEOLEVEL2* shapes is extracted and then divided by the sum of the population living in the same sub-national unit. In this way the normalized population-weighted average time invariant lightning strikes measure is obtained.

These procedures ensure that both the 2G mobile coverage share and the instrumental variable, lightning strikes, are appropriately population-weighted, providing robustness to the empirical analysis by reducing the scope of the measurement error.

Appendix A.2. Absence of 3G Coverage

Our sample period (2006–2014) captures the early phases of 3G infrastructure rollout across several countries. In our sample, Egypt conducted its second survey in 2006, at the very beginning of 3G deployment when the network was available only in a few regions. Around the same time, El Salvador and Colombia carried out their second survey waves in 2007, when they did not yet have any 3G coverage. Guinea, which appears in the second survey wave in 2014, exhibits very limited 3G coverage. Figure A.1 shows a map that visually illustrates the very sparse spatial distribution of the 3G network in Guinea.

Figure A.1: 3G coverage in Guinea 2014



Notes: We plot the raw 3G coverage spread in Guinea in 2014 during the second wave.

Appendix B. Instrument Robustness

We present an array of tests and partial assumptions relaxations to ensure the relevance and robustness of the instrument in our empirical specifications. We employ a single endogenous regressor and a single instrument, so we report the Kleibergen-Paap statistic, the equivalent of the effective F-statistic recommended by Olea and Pflueger (2013) in our one-instrument setting with clustered standard errors. In our main tables, the Olea and Pflueger (2013) statistic takes a value that exceeds the rule-of-thumb threshold of 10, ruling out weak-instrument concerns.

In Table B1, we re-estimate variations of Equation 2 for robustness to our main specification (shown in Table 1). We use a different set of controls, region plus wave FE instead of region plus continent times wave FE in Column 3, we control for time varying rain instead of time invariant rain in Column 1, we use time variant socio-demographics instead of time invariant ones in Column 2 and finally in Column 4 we control for baseline levels of oil resources, probability of droughts, shares of herb land and roughness of the terrain.

Table B1: First Stage: Alternative specifications

	(1)	(2)	(3)	(4)
Strikes	−2.489*	−2.438*	−2.446**	−2.342**
	(1.070)	(1.011)	(0.770)	(0.774)
# Obs.	4080	4080	4080	4080
# Countries	13	13	13	13
R^2	0.75	0.75	0.74	0.75
Region FE	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	No	Yes
Wave FE	No	No	Yes	No
Rain Controls	No	Yes	Yes	Yes
Time Variant Rain	Yes	No	No	No
Time variant Socio-Demo	No	Yes	No	No
Further Geo-controls	No	No	No	Yes
Mean Dep. Var.	0.26	0.26	0.26	0.26

Notes: This table presents the first-stage regression results using alternative specifications. We use a different set of controls, region plus wave FE instead of region plus continent times wave FE in Column 1, we control for time varying rain instead of time invariant rain in Column 2, we use time variant socio-demographics instead of time invariant ones in Column 3 we use region + wave FE instead of region + continent × wave FE and in Column 4 we control for baseline levels of oil resources, probability of droughts, shares of herb land and roughness of the terrain. In all four models, we employ the same setting of our preferred specification (Column 3 in Table 1) Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Then we show in Table B2 that the first-stage relationship is robust across the three different sample configurations we effectively use by running the 2SLS specification in different outcome categories exhibiting different data availability characteristics.

Table B2: First Stage across Samples

	(1)	(2)
Lightning Strikes	−2.266*	−2.922***
	(0.795)	(0.730)
# Obs.	2988	3794
# Countries	9	12
R^2	0.79	0.76
Region FE	Yes	Yes
Continent × Wave FE	Yes	Yes
Mean Dep. Var.	0.29	0.27

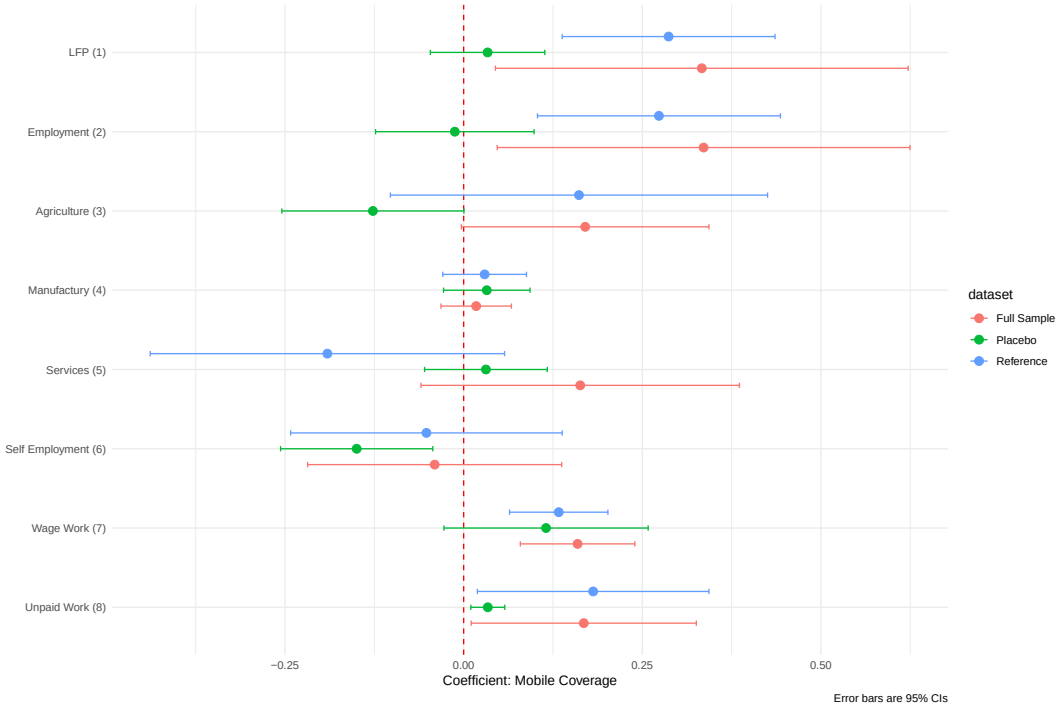
*Notes:*This table presents the first-stage regression results using a continuous instrumental variable (*cont_iv*) that measures the share of the population affected by lightning strikes, normalized between 0 and 1. Both models include controls for baseline (1990) rain levels interacted with a linear time trend to address potential multicollinearity between lightning strikes and socio-economic factors influencing both 2G mobile coverage and second-stage outcomes. Standard errors, reported in parentheses, are clustered at the GEOLEV2 level, the unit of treatment variation. The two samples represent different subsets of the dataset: in Column (1) we report the first stage for the subsample of countries that report sectoral information, while in Column (2) we report the first stage for the subsample that reports employment type information. Statistical significance levels are denoted as follows: *** p < 0.001, ** p < 0.01, * p < 0.05, + p < 0.1.

Appendix C. Robustness (2SLS)

Appendix C.1. Placebos

One of the main threats to our micro LATE identification is the presence of differences in the pre-trends between treated and control regional units in our sample, which we might be capturing with our estimation. To speak to these concerns, we set up a placebo setting for the countries that have IPUMS-International outcomes for previous periods. In this way, we build a three-appearance sample for six out of 13 countries, and we shift the treatment to the early ´90s, the period that is considered the baseline in the reference design. We then estimate the effect by having as a baseline the data from the ´80s. In Table G10 and Table G11 we table the results of the placebo regressions that are summarized in Figure C1.

Figure C1: Placebo 2SLS vs estimates for countries for which we have data



Notes: Plotting coefficients corresponding to regressions reported in Table G10 and Table G11 with their corresponding confidence intervals.

Appendix C.2. FE Combinations

Here we present in Table C1, Table C2, Table C3, the same outcomes of the main analysis for different FE combinations and with the addition of a larger set of demographic controls as well as run on slightly different sample composition.

Table C1: 2SLS Regional FE: Employment share

	Labor Part (1)	Emp Tot (2)	Emp Active (3)
Mobile Coverage	0.240	0.250+	0.065
	(0.153)	(0.136)	(0.052)
# Obs.	4080	4080	4080
# Countries	13	13	13
Region FE	Yes	Yes	Yes
Wave FE	Yes	Yes	Yes
Mean Outcome	0.23	0.08	0.20
Wald F-stat	5.40	5.40	5.40

Notes: This table presents the 2SLS results on employment shares. Columns (1)-(3) report estimates for the total sample using only regional fixed effects, and columns (4)-(6) report estimates for the labor-active sample using the same fixed effects. In all models, we control for rain at baseline (in 1990) and diamond and gold vein presence and extent at baseline interacted with a wave dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table C2: 2SLS Regional FE: Sectoral Outcomes

	Agriculture (1)	Manufactury (2)	Service (3)
Mobile Coverage	0.181*	0.010	0.088
	(0.072)	(0.025)	(0.096)
Mean Dep. Var.	0.23	0.08	0.20

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level on the employment sectors (agriculture, manufacturing, and services) shares as outcomes. Models are grouped into three panels corresponding to total, labor active, and employed sample results. In all models, we control for rain at baseline (in 1990) and diamond and gold vein presence and extent at baseline interacted with a wave dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table C3: 2SLS Regional FE: Employment Type Outcomes

	Self Emp (1)	Wage Work (2)	Unpaid Work (3)
Mobile Coverage	0.002	0.145***	0.065
	(0.081)	(0.034)	(0.046)
Mean Dep. Var.	0.24	0.25	0.09

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level on the employment types (self-employment, wage work, unpaid work, and other employment) shares as outcomes. Models are grouped into three panels corresponding to total, labor active, and only employed individuals' sample results. In all models, we control for rain at baseline (in 1990) and diamond and gold vein presence and extent at baseline interacted with a wave dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Appendix C.3. Control Functions

In addition to our baseline 2SLS estimates, Table C5 (sectoral employment shares), Table C6 (employment-type shares) and Table C4 (aggregate employment and labor-force participation)

report results from a control–function (CF) specification. In each CF regression, we first estimate the reduced-form of our endogenous regressor (Mobile Coverage) on the instrument (Lightning Strikes) and the baseline rain plus baseline resource controls (diamonds and gold veins) using our regional and continent times year FEs and save the residuals. We then re-estimate the outcome equation, including both the Mobile Coverage and its residual; the residual term "soaks up" any remaining covariance between Mobile Coverage and unobserved determinants of the labor market outcomes. Standard errors are two-way clustered (region and country-year). Compared to 2SLS, the CF approach imposes a linear residual-inclusion assumption rather than relying solely on orthogonality, which (i) permits a direct exogeneity test via the residual's significance and (ii) can improve efficiency under correct specification. The fact that the CF estimates for our key coefficients remain quantitatively and statistically similar to the 2SLS results provides further reassurance that our findings are robust to functional-form assumptions and weak-instrument concerns.

Table C4: Control Functions: Employment Outcomes

	Emp	Labor part
Mobile Coverage	0.324***	0.333***
	(0.020)	(0.020)
Residuals FS	−0.318***	−0.328***
	(0.021)	(0.021)
Rain	1.523***	1.794***
	(0.404)	(0.318)
# Obs.	4080	4080
# Countries	13	13
R^2	0.901	0.902

*Notes:*This table presents the results of the Control Functions regressions on the employment shares and labor force participation shares outcomes using fixed effects at the regional level and continent-by-year fixed effects. In all three models, we control for rain at baseline (in 1990) and diamond and gold vein presence and extent at baseline interacted with a wave dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table C5: Control Functions: Sectoral Employment Shares

	Agri	Manuf	Serv
Mobile Coverage	0.155***	0.016+	−0.013
	(0.020)	(0.010)	(0.021)
Residual FS	−0.158***	−0.024*	0.018
	(0.021)	(0.011)	(0.022)
Rain	1.282***	0.016	−0.988*
	(0.310)	(0.103)	(0.448)
# Obs.	3274	3274	3274
# Countries	10	10	10
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
R^2	0.968	0.896	0.916

*Notes:*This table presents the results of the Control Functions regressions on the three sectoral employment shares outcomes using fixed effects at the regional level and continent-by-year fixed effects. In all three models, we control for rain at baseline (in 1990) and diamond and gold vein presence and extent at baseline interacted with a wave dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table C6: Control Functions: Employment Types Shares

	Self-emp	Wage work	Unpaid work	Other emp
Mobile Coverage	−0.069***	0.153***	0.164***	−0.003*
	(0.020)	(0.013)	(0.016)	(0.001)
Residuals FS	0.060**	−0.152***	−0.140***	0.003**
	(0.020)	(0.013)	(0.015)	(0.001)
Rain	−0.653*	0.618*	0.661***	−0.022+
	(0.261)	(0.299)	(0.199)	(0.012)
# Obs.	3674	3674	3674	3674
# Countries	12	12	12	12
Region FE	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes
R^2	0.922	0.963	0.917	0.878

*Notes:*This table presents the results of the Control Functions regressions on the three employment types shares outcomes using fixed effects at the regional level and continent-by-year fixed effects. In all three models, we control for rain at baseline (in 1990) and diamond and gold vein presence and extent at baseline interacted with a wave dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Appendix D. Mechanism Robustness

Appendix D.1. Production Orientation

We report in Table F1 a summary of how the degree of production orientation of regions from countries in the sample.

And in Table F2 the first stage with the production orientation interaction for both the full and the active sample in the 10 countries that report information on the employment type (excluding Bangladesh, Uganda and Guinea from the full main specification sample).

Then we report the estimates for the 2SLS regression on the full sample.

Table F1: Summary of Production Orientation across Sample countries

Country	Mean Production Orientation	Mean Consumption Orientation
Benin	0.746	0.254
Cambodia	0.874	0.126
Chile	0.655	0.345
Colombia	0.701	0.299
Egypt	0.564	0.436
El Salvador	0.735	0.265
Malaysia	0.671	0.329
Mozambique	0.890	0.110
Paraguay	0.686	0.314
Venezuela	0.676	0.324
Missing information for		
Uganda	NA	NA
Bangladesh	NA	NA
Guinea	NA	NA

Notes: Production Orientation is the proportion of total regional employment concentrated in tradable sectors. It is computed by first summing employment in manufacturing, mining and extraction, electric and gas utilities, business services, financial services, transport and storage, and agriculture/ fishing/ forestry, then dividing that sum by total employment in the region. Consumption Orientation is the proportion of total employment in non-tradable sectors, computed by summing employment in construction, wholesale and retail trade, education, health and social work, and public administration, and dividing by total regional employment. All missing sector values were set to zero before aggregation; regions with zero total employment are assigned missing shares.

Table F2: First Stage with Production Orientation Interactions

	(1))
Strikes	-1.927**
	(0.7281)
Strikes × Trade share	-2.666***
	(0.4702)
# Obs.	3274
# Countries	10
R^2	0.948
Region FE	Yes
Continent × Wave FE	Yes

Notes: This table presents the results of the first-stage regressions with the interaction between both the instrument and the mobile coverage with the production orientation share of each region. In column one the full sample, in column 2 the a labor active sample, and in column 3 the sample where we exclude Mozambique for which we have no employment type outcome. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

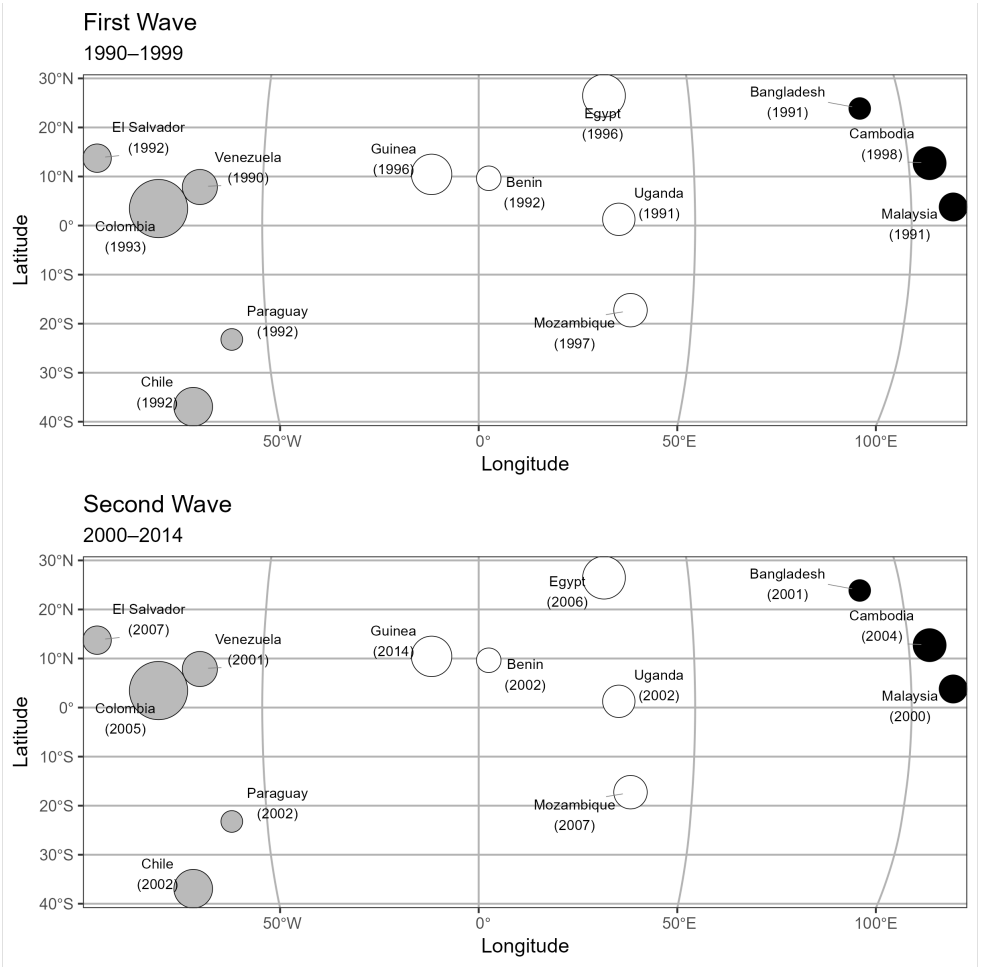
Table F3: 2SLS Production Orientation Heterogeneities - Full sample

	Emp (1)	LFP (2)	Wage Work (3)	Unpaid Work (4)	Self Emp (5)
Mobile Coverage	0.303	0.336	0.204*	0.038	0.070
	(0.186)	(0.197)	(0.074)	(0.034)	(0.138)
Mobile Coverage × Share Trade	0.110+	0.127+	0.089**	0.023	0.007
	(0.063)	(0.069)	(0.025)	(0.016)	(0.039)
# Obs.	3274	3274	2988	2988	2988
# Countries	12	12	9	9	9
Mean dep. var	0.57	0.61	0.25	0.09	0.24
Wald F-stat	28.82	28.82	33.87	33.87	33.87
Region FE	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the results of the second stage-stage regressions with the interaction between both the instrument and the mobile coverage with the production orientation share of each region. In this table we report estimates for the full sample on countries we have available information on both the outcomes and the production orientation. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$. respectively.

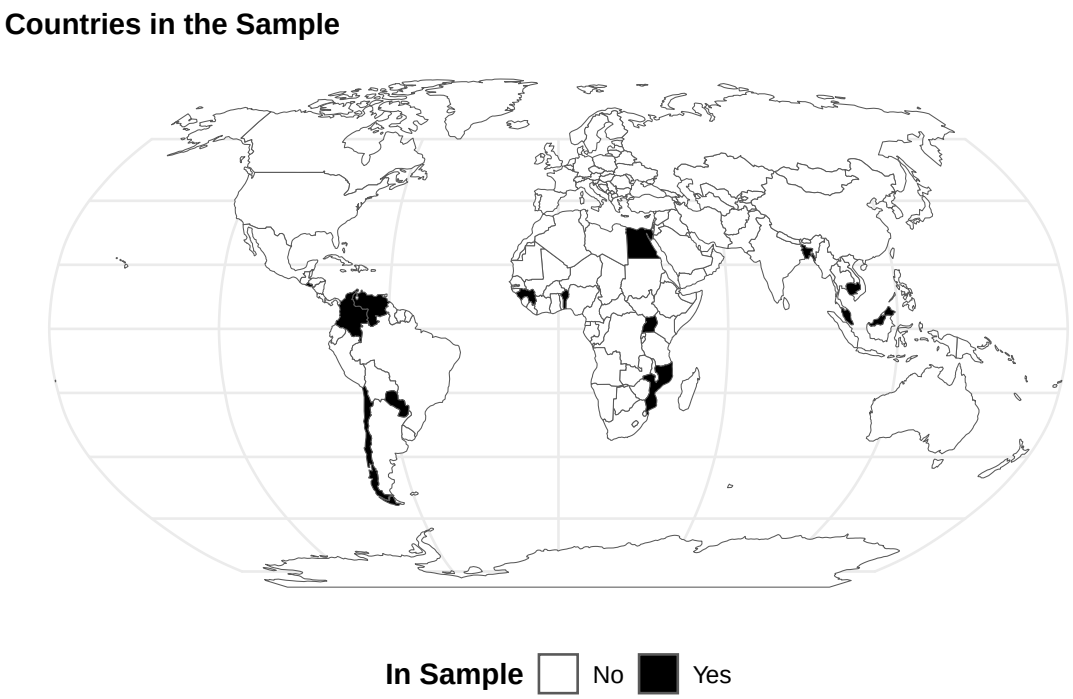
Appendix E. Figures

Figure E1: Doerling Cartogram of Countries in the Sample



Notes: Showing the Doerling Cartogram of our countries in the two appearances in the sample.

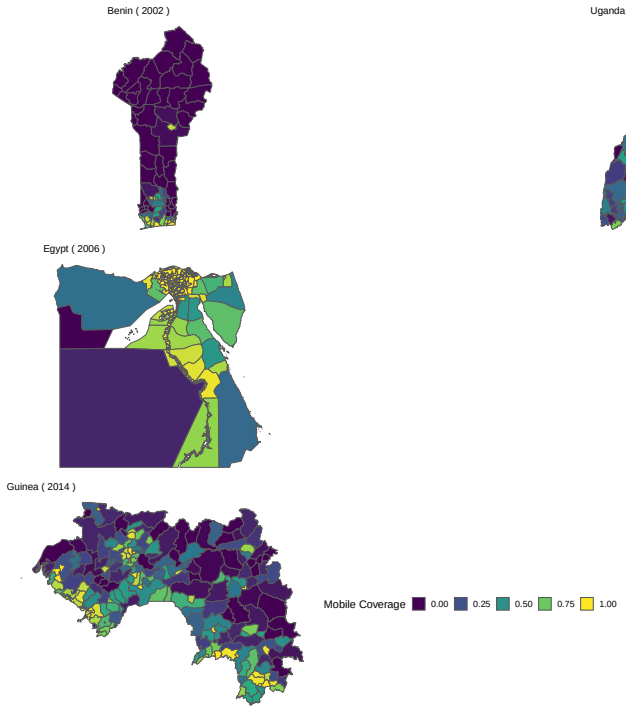
Figure E2: Countries in the sample



Notes: Plotting the areas of the countries in the sample colored in black. Using R-NaturalEarth 2024 shapes for the borders.

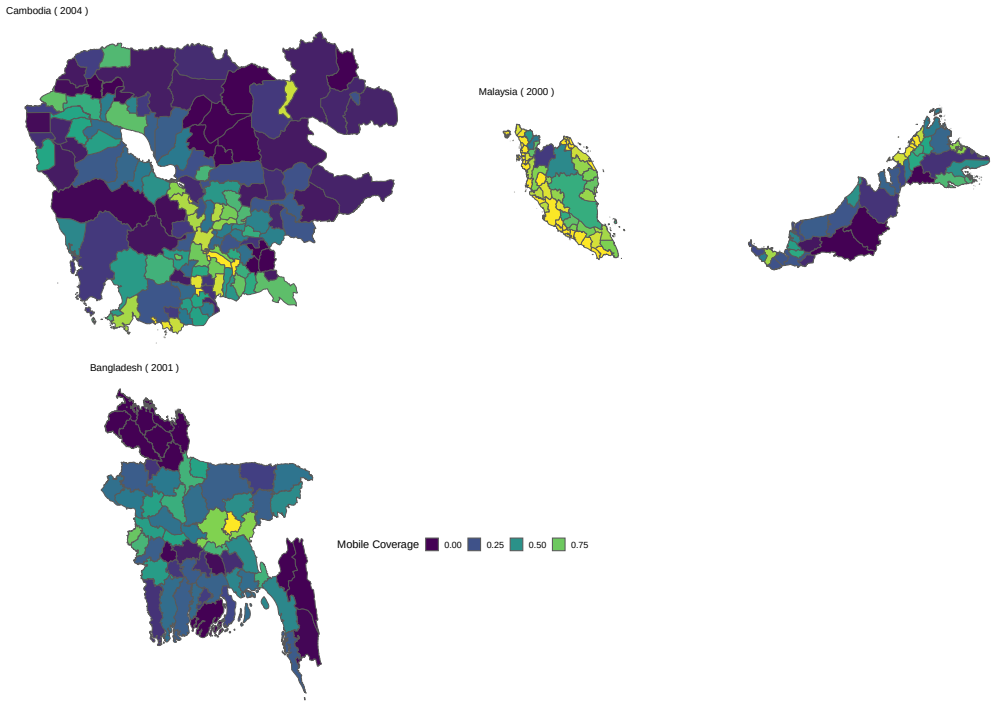
Here, we show the countries in the sample by continent, plotting the administrative units colored by the share of the population with 2G access in the second appearance.

Figure E3: Coverage in the second appearance for African countries in the sample



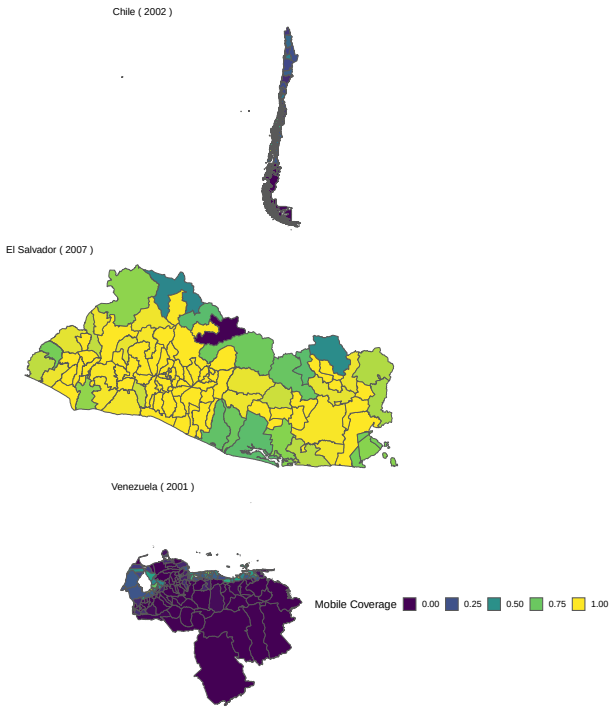
Notes: Plotting the share of the population covered by 2G infrastructure in each of the regions in our sample during the second wave in African countries.

Figure E4: Coverage in the second appearance for Asian countries in the sample



Notes: Plotting the share of the population covered by 2G infrastructure in each of the regions in our sample during the second wave in Asian countries.

Figure E5: Coverage in the second appearance for American countries in the sample



Notes: Plotting the share of the population covered by 2G infrastructure in each of the regions in our sample during the second wave in American countries.

Appendix F. Tables

Table G1: IPUMS-International Sector Codes - INDGEN

Code	Sector	Grouped Sector
010	Agriculture, fishing, and forestry	Primary
020	Mining and extraction	Primary
030	Manufacturing	Secondary
040	Electricity, gas, water, and waste management	Tertiary
050	Construction	Primary
060	Wholesale and retail trade	Tertiary
070	Hotels and restaurants	Tertiary
080	Transportation, storage, and communications	Tertiary
090	Financial services and insurance	Tertiary
100	Public administration and defense	Tertiary
110	Services, not specified	Tertiary
111	Business services and real estate	Tertiary
112	Education	Tertiary
113	Health and social work	Tertiary
114	Other services	Tertiary
120	Private household services	Tertiary
130	Other industry, n.e.c.	Tertiary

Notes: We report the categorization of Industry variables as given by IPUMS-International https://international.ipums.org/international-action/variables/INDGEN#codes_section and used by us in the analysis.

Appendix F.1. Waves of Adoption

Table G2: Overview of adoption years (2G and 3G) and sample appearances

Country	Date Wave 2	Rollout 2G	Rollout 3G
Bangladesh	2001	2001	2012
Benin	2002	2001	2013
Cambodia	2004	1999	2009
Chile	2002	2000	2014
Colombia	2005	2004	2012
Egypt	2006	2005	2009
El Salvador	2007	2001	2014
Guinea	2014	2006	2014
Malaysia	2000	1998	2009
Mozambique	2007	1997	2012
Paraguay	2002	2010	2014
Uganda	2002	2000	2010
Venezuela	2001	2006	2012

Notes: This table presents an overview for the countries in our sample of the year when 2G and 3G were adopted, following official International Telecommunication Union (ITU) data together with the year in which each country is observed for the second wave of the survey used for our empirical design. It is clear from the overview how the second wave always happens after the introduction of 2G and before the introduction of 3G.

Appendix F.2. OLS Baseline

Table G3: OLS: Labor Market Outcomes

	Manuf. (1)	Agri (2)	Serv. (3)	Self Emp (4)	Wage Emp (5)	Unpaid Emp(6)	LFP(7)	Emp (8)
Mobile Coverage	−0.008	0.007	0.010	−0.001	0.009	0.039*	0.025	0.022
	(0.009)	(0.016)	(0.020)	(0.020)	(0.011)	(0.016)	(0.016)	(0.016)
R^2	0.885	0.959	0.867	0.917	0.963	0.915	0.893	0.897
# Obs.	2988	2988	2988	3794	3794	3794	4080	4080
# Countries	9	9	9	12	12	12	13	13
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.08	0.23	0.20	0.24	0.25	0.09	0.61	0.57

Notes: This table presents the results of the OLS regressions with fixed effects at the GEOLEV2 level and continent × appearance level on all 8 regional labor market outcomes shares in the analysis ((1) Manufacturing, (2) Agriculture, (3) Service, (4) Self Employment, (5) Wage Employment, (6) Unpaid Employment, (7) Labor Participation, and (8) Overall Employment). All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Appendix F.3. Reduced Forms

Table G4: Reduced Form: Labor market outcomes on Full Sample

	Manuf (1)	Agri (2)	Serv (3)	Self Emp (4)	Wage Emp (5)	Unpaid Emp (6)	LFP (7)	Emp (8)
Lightining Strikes	−0.027	−0.557***	−0.372+	−0.003	−0.397**	−0.506*	−0.952***	−0.932***
	(0.047)	(0.133)	(0.191)	(0.237)	(0.125)	(0.200)	(0.158)	(0.147)
R^2	0.884	0.961	0.869	0.917	0.965	0.916	0.904	0.906
# Obs.	2988	2988	2988	3794	3794	3794	4080	4080
# Countries	9	9	9	12	12	12	13	13
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.08	0.23	0.20	0.24	0.25	0.09	0.61	0.57

Notes: This table presents the results of the Reduced form regressions with fixed effects at the regional level and continent * appearance level on a categorical education outcome. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$. respectively.

Table G5: Reduced Form: Education Outcomes - Full Sample

	Primary (1)	Secondary (2)	University (3)
Lightining Strikes	0.369*	−0.342*	−0.006
	(0.145)	(0.125)	(0.076)
R^2	0.961	0.972	0.933
# Obs.	4080	4080	4080
# Countries	13	13	13
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Mean Dep. Var.	0.30	0.13	0.02

Notes: This table presents the results of the Reduced form regressions with fixed effects at the regional level and continent * appearance level on a categorical education outcome. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Appendix F.4. 2SLS Active and Employed Samples

Appendix F.5. Placebos

Table G6: OLS: Education Outcomes - Full Sample

	Primary (1)	Secondary (2)	University (3)
Mobile Coverage	−0.028+	0.027**	0.019***
	(0.015)	(0.009)	(0.004)
R^2	0.961	0.972	0.940
# Obs.	4080	4080	4080
# Countries	12	12	12
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Mean Dep. Var.	0.30	0.13	0.02

Notes: This table presents the results of the OLS regressions with fixed effects at the regional level and continent * appearance level on a categorical education outcome. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G7: 2SLS: Employment Type Active Samples

	Self Emp (1)	Wage Work (2)	Unpaid Work (3)
Panel A: Active Sample			
Mobile Coverage	−0.210	0.114	0.166*
	(0.155)	(0.123)	(0.072)
Mean Dep. Var.	0.37	0.47	0.11
Wald F-stat	16.00	16.00	16.00
Obs.	3794	3794	3794
# Countries	12	12	12
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent × appearance level on the employment types (self-employment, wage work, unpaid work, and other employment) shares as outcomes. Models are run only on labor-active individuals' sample results. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G8: 2SLS: Employment Type Employed Samples

Mobile Coverage	−0.265	0.096	0.160*
	(0.167)	(0.131)	(0.072)
Obs.	3794	3794	3794
# Countries	12	12	12
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes
Mean Dep. Var.	0.39	0.49	0.12
Wald F-stat	16.00	16.00	16.00

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent × appearance level on the employment types (self-employment, wage work, unpaid work, and other employment) shares as outcomes. Models are run on samples including only employed individuals' sample results. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G9: 2SLS: Employment Sector Active and Employed Samples

	Agriculture (1)	Manufactury (2)	Services (3)
Panel A: Active Sample			
Mobile Coverage	0.281*	−0.043	−0.042
	(0.119)	(0.037)	(0.041)
Dep. Var.	0.41	0.14	0.39
Wald F-stat	5.73	5.73	5.73
Panel B: Employed Sample			
Mobile Coverage	0.213*	−0.058	−0.165*
	(0.099)	(0.040)	(0.068)
# Obs.	2988	2988	2988
# Countries	10	10	10
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes
Mean Dep. Var.	0.42	0.15	0.42
Wald F-stat	8.12	8.12	8.12

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional and continent times appearance level on the employment sectors (agriculture, manufacturing, and services) shares as outcomes. Models are grouped into two panels corresponding to labor active and employed sample results. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G10: 2SLS: Placebo from the 80s

	Agriculture (1)	Manufactury (2)	Services (3)	Primary (4)	Secondary (5)	University (6)	LFP (7)	Employment (8)	Self Employment (9)	Unpaid Work (10)	Wage Work (11)
Mobile Coverage	−0.277*	0.087	0.187**	−0.062+	0.182***	0.043**	0.033	−0.012	−0.150**	0.034**	0.115
	(0.098)	(0.048)	(0.057)	(0.030)	(0.033)	(0.013)	(0.037)	(0.051)	(0.049)	(0.011)	(0.066)
# Obs.	1816	1816	1816	2458	2458	2458	2458	2458	2458	2458	2458
# Countries	7	7	7	7	7	7	7	7	7	7	7
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.32	0.13	0.30	0.29	0.10	0.02	0.56	0.44	0.16	0.04	0.24
Wald F-stat	8.15	8.15	8.15	6.23	6.23	6.23	6.23	6.23	6.23	6.23	6.23

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times appearance level on labor force participation, employment, sectoral employment, and education outcomes. The table is a placebo where we use the 7 countries [14] that have available older data (from the 80s) and we assign the treatment to the 90s in a placebo fashion, using the 80s as a control group. All models are run on the full sample of 7 countries with available data, controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G11: 2SLS: Placebo Reference results

	Agriculture (1)	Manufactury (2)	Services (3)	Primary (4)	Secondary (5)	University (6)	LFP (7)	Emp (8)	Self Emp (9)	Unpaid Work (10)	Wage Work (11)
Mobile Coverage	0.161	0.029	−0.191	−0.087**	0.142*	0.009	0.287**	0.273**	−0.052	0.181*	0.133**
	(0.121)	(0.027)	(0.114)	(0.027)	(0.053)	(0.034)	(0.069)	(0.079)	(0.088)	(0.075)	(0.032)
Obs.	2559	2559	2559	2768	2768	2768	2768	2768	2458	2458	2458
# Countries	7	7	7	7	7	7	7	7	7	7	7
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rain Control	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.40	0.16	0.44	0.33	0.17	0.03	0.56	0.52	0.20	0.04	0.29
Wald F-stat	5.15	5.15	5.15	8.47	8.47	8.47	8.47	8.47	6.23	6.23	6.23

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times appearance level on labor force participation, employment, sectoral employment and education outcomes. The table is the reference for the placebo analysis where we use the 7 countries that have available older data (from the 80s) but without reassigning the treatment as placebo and without using the data from the 80s. All models are run on the full sample of 7 countries having available data, controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Appendix F.6. 2SLS Robustness

Table G12: 2SLS: LFP and Employment Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mobile Coverage	0.240	0.368*	0.389**	0.395*	0.250+	0.381*	0.380**	0.382*
	(0.153)	(0.156)	(0.132)	(0.143)	(0.136)	(0.156)	(0.132)	(0.140)
# Obs.	4080	4080	4080	4080	4080	4080	4080	4080
# Countries	13	13	13	13	13	13	13	13
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	No	Yes	Yes	Yes	No	Yes
Wave FE	No	No	Yes	No	No	No	Yes	No
Rain Controls	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Time Variant Rain	Yes	No	No	No	Yes	No	No	No
Mean Outcome	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Wald F-stat	5.40	5.81	10.08	9.16	5.40	5.81	10.08	9.16

Notes: This table reports the results of the 2SLS regressions for two outcome variables: labor force participation (Columns 1–4) and employment (Columns 5–8). Each block of four columns applies alternative robustness specifications. In Column 1 and 5 we include region and wave fixed effects instead of region plus continent-by-wave fixed effects; in Column 2 and 6 we control for time-varying rainfall rather than time-invariant rainfall; in Column 3 and 7 we use time-varying socio-demographics instead of time-invariant ones; and in Column 4 and 8 we additionally control for baseline levels of oil resources, probability of droughts, shares of herb land, and terrain roughness. In all four specifications, we otherwise follow the setting of our preferred first-stage specification (Column 3 in Table 1). Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G13: 2SLS: Sectors Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mobile Coverage	0.181*	0.227+	0.245*	0.265*	0.010	0.031	0.012	0.016	0.088
	(0.072)	(0.111)	(0.103)	(0.113)	(0.025)	(0.025)	(0.021)	(0.027)	(0.096)
# Obs.	2988	2988	2988	2988	2988	2988	2988	2988	2988
# Countries	9	9	9	9	9	9	9	9	9
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Wave FE	Yes	No	No	No	Yes	No	No	No	Yes
Rain Controls	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Time Variant Rain	No	No	Yes	No	No	No	Yes	No	No
Mean Dep. Var.	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29
Wald F-stat	8.80	5.32	8.14	6.56	8.80	5.32	8.14	6.56	8.80

Notes: This table reports the results of the 2SLS regressions for three sectoral outcomes: agriculture (Columns 1–4), manufacturing (Columns 5–8), and services (Columns 9–12). Each block of four columns applies the same set of alternative robustness specifications. Specification (1) includes region and wave fixed effects instead of region plus continent-by-wave fixed effects; Specification (2) controls for time-varying rainfall rather than time-invariant rainfall; Specification (3) uses time-varying socio-demographics instead of time-invariant ones; and Specification (4) additionally controls for baseline levels of oil resources, probability of droughts, shares of herb land, and terrain roughness. In all cases, we otherwise follow the setting of our preferred first-stage specification (Column 3 in Table 1). Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G14: 2SLS: Employment Types Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Mobile Coverage	0.002	−0.049	0.001	−0.013	0.145***	0.180***	0.135***	0.125**	0.0
	(0.081)	(0.088)	(0.081)	(0.076)	(0.034)	(0.045)	(0.030)	(0.034)	(0.0
# Obs.	3794	3794	3794	3794	3794	3794	3794	3794	379
# Countries	12	12	12	12	12	12	12	12	12
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No
Wave FE	Yes	No	No	No	Yes	No	No	No	Yes
Rain Controls	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Time Variant Rain	No	No	Yes	No	No	No	Yes	No	No
Mean Dep. Var.	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.2
Wald F-stat	8.92	9.40	15.68	16.27	8.92	9.40	15.68	16.27	8.9

Notes: This table reports the results of the 2SLS regressions for three employment types: self-employment (Columns 1–4), wage work (Columns 5–8), and unpaid work (Columns 9–12). Each block of four columns applies the same set of alternative robustness specifications. Specification (1) includes region and wave fixed effects instead of region plus continent-by-wave fixed effects; Specification (2) controls for time-varying rainfall rather than time-invariant rainfall; Specification (3) uses time-varying socio-demographics instead of time-invariant ones; and Specification (4) additionally controls for baseline levels of oil resources, probability of droughts, shares of herb land, and terrain roughness. In all cases, we otherwise follow the setting of our preferred first-stage specification (Column 3 in Table 1). Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Appendix F.7. Detailed Employment Outcomes

Table G15: Agriculture Detailed Outcomes

	Tot Agriculture	Agri-Fish and Forestry	Mining Extraction
	(1)	(2)	(3)
Mobile Coverage	0.2459**	0.2308**	0.0152
	(0.1056)	(0.0979)	(0.0174)
Mean Dep. Var.	0.265	0.260	0.005
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
First Stage F Stat	152.64	152.64	152.64
# Obs.	2,988	2,988	2,988
# Countries	9	9	9
Wald F. Stat	18.7	18.7	18.7

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times wave level on detailed agricultural outcomes. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy.Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G16: Manufactury Detailed Outcomes

	Tot Manuf	Manufacturing	Construction
	(1)	(2)	(4)
Mobile Coverage	0.0120	-0.0181	0.0300**
	(0.0205)	(0.0154)	(0.0104)
Mean Dep. Var.	0.077	0.048	0.028
Region FE	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes
Wald F Stat	18.7	18.7	18.7
# Obs.	2,988	2,988	2,988
# Countries	9	9	9

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times wave level on detailed manufacturing outcomes. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy.Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G17: Services Detailed Outcomes

Panel A

	Tot Serv	Electricity & Gas	Retail	Hospitality	Transport	Finance	Public Admin
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Mobile Coverage	0.1640	0.0016	0.1365*	-0.0328	0.0125	-0.0042	0.0174
	(0.1075)	(0.0013)	(0.0661)	(0.0192)	(0.0084)	(0.0065)	(0.0170)
Mean Dep. Var.	0.194	0.002	0.062	0.010	0.020	0.003	0.021
# Countries	9	9	9	9	9	9	9
# Obs.	2,988	2,988	2,988	2,988	2,988	2,988	2,988

Panel B

	Unspec.	Business	Education	Health	Other	Household
	(8)	(9)	(10)	(11)	(12)	(13)
Mobile Coverage	-0.0427	0.0603***	-0.0082	0.0272*	-0.0425	0.0388*
	(0.0380)	(0.0178)	(0.0187)	(0.0143)	(0.0246)	(0.0221)
Mean Dep. Var.	0.002	0.010	0.023	0.011	0.015	0.014
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
Wald F Stat	18.7	18.7	18.7	18.7	18.7	18.7
# Obs.	2,988	2,988	2,988	2,988	2,988	2,988
# Countries	9	9	9	9	9	9

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times wave level on detailed service outcomes. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G18: Wage Work Detailed Outcomes

Panel A: Wage outcomes

	Tot Wage	Wage	White	Blue	White/Blue	Day lab	Perm
Mobile Coverage	0.1359***	-0.2470	0.0300	0.0801	0.2506*	0.0087	0.0624
	(0.0309)	(0.1547)	(0.0206)	(0.0546)	(0.1329)	(0.0128)	(0.0667)
Mean Dep. Var.	0.252	0.156	0.001	0.003	0.031	0.005	0.010

Panel B: Wage outcomes

	Occ.	Private	Apprent	Coop.	Public	Domestic	Parastatal
Mobile Coverage	0.0157	-0.0368	-0.0007	-2.31×10^{-5}	-0.0421	0.0060	0.0019
	(0.0226)	(0.0501)	(0.0007)	(3.93×10^{-5})	(0.0393)	(0.0135)	(0.0011)
Mean Dep. Var.	0.004	0.021	0.001	0.000	0.008	0.009	0.000
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cont. × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Wald F Stat	9.79	9.79	9.79	9.79	9.79	9.79	9.79
# Obs.	3,794	3,794	3,794	3,794	3,794	3,794	3,794
# Countries	12	12	12	12	12	12	12

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times wave level on detailed wage work outcomes. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Appendix F.8. Within Sector outcomes

Appendix F.9. First stages from Heterogeneities

Table G19: Self Employment Detailed Outcomes

	Tot Self-emp.	New Self-emp.	Employer	Own-account	Coop.	Sharecrop
Mobile Coverage	0.0011	0.0072	-0.0070	-0.0148	0.0014	-0.0010
	(0.0812)	(0.0130)	(0.0107)	(0.0707)	(0.0014)	(0.0009)
Mean Dep. Var.	0.238	0.021	0.016	0.197	0.001	0.000
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Cont. × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes
Wald F Stat	9.79	9.79	9.79	9.79	9.79	9.79
# Obs.	3,794	3,794	3,794	3,794	3,794	3,794
# Countries	12	12	12	12	12	12

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times wave level on detailed self employment outcomes. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G20: Unpaid Detailed Outcomes

	Tot Unpaid (1)	Family (2)	Apprentice (3)	No-Wage (4)	Other (5)
Mobile Coverage	0.1733**	-0.0125***	0.1866**	-0.0009	-0.0032
	(0.0635)	(0.0040)	(0.0665)	(0.0011)	(0.0035)
Mean Dep. Var.	0.088	0.001	0.087	0.000	0.003
Region FE	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes
Wald F Stat	9.79	9.79	9.79	9.79	9.79
# Obs.	3,794	3,794	3,794	3,794	3,794
# Countries	12	12	12	12	12

Notes: This table presents the results of the 2SLS regressions with fixed effects at the regional level and continent times wave level on detailed unpaid work outcomes. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G21: Within Sectoral Outcomes

	Agri Self (1)	Agri Wage (2)	Agri Unpaid (3)	Manuf Self (4)	Manuf Wage (5)	Manuf Unpaid (6)	Serv Self (7)	Serv Wage (8)	Serv Unpaid (9)
Mobile Coverage	−0.225+	0.327*	0.864	0.139	−0.044	0.294*	0.120*	−0.275*	0.453*
	(0.119)	(0.131)	(0.627)	(0.092)	(0.057)	(0.108)	(0.054)	(0.114)	(0.203)
# Obs.	2988	2988	2988	2988	2988	2988	2988	2988	2988
# Countries	9	9	9	9	9	9	9	9	9
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continent × Wave FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Dep. Var.	0.47	0.28	0.53	0.16	0.18	0.10	0.37	0.53	0.23
Wald F-stat	8.12	8.12	8.12	8.12	8.12	8.12	8.12	8.12	8.12

Notes: This table presents the results of the 2SLS regressions on the shares of employment type by sectors. Models 1 3 are referred to as Agriculture, Models 4 6 to Manufacturing and Models 7 9 to Services. The specification order is first the share of self-employed, then the shares of wage workers, and then the shares of unpaid workers. All models are run controlling for baseline (1990) level of rain interacted with a linear time trend to control for potential multicollinearity, and time-invariant sociodemographics (age, age squared, and gender), and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are two-way clustered at the regional and country-year levels and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G22: First stage: Gender Heterogeneities

	(1)
Lightning Strikes	−2.280
	(1.377)
Lightning Strikes × Gender	−0.264
	(0.577)
# Obs.	8160
# Countries	8160
R^2	0.423
Region FE × Female	Yes
Continent × Wave FE	Yes

Notes This table presents the results of the 2SLS regressions of mobile coverage on employment outcomes run within a sample of gender-wave-region cells. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G23: First stage: Age Heterogeneities

	(1)
Strikes	−0.527
	(1.175)
Strikes × Older	−3.465***
	(0.507)
# Obs.	8160
# Countries	13
R^2	0.773
Region × Older FE	Yes
Continent × Wave FE	Yes

Notes This table presents the results of the 2SLS regressions of mobile coverage on employment outcomes run within a sample of age split-wave-region cells, with the age split being the median age in the sample, 32 years old. All models are run on the full sample, controlling for time-invariant socio-demographics (gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.

Table G24: First stage: Education Heterogeneities

	(1)
Strikes	−2.405*
	(0.916)
Strikes × Older	0.144
# Obs.	8142
# Countries	13
R^2	0.757
Region × Older FE	Yes
Continent × Wave FE	Yes

Notes This table presents the results of the 2SLS regressions of mobile coverage on employment outcomes run within a sample of education split-wave-region cells, where the education split is the presence of a completed secondary education degree. All models are run on the full sample, controlling for time-invariant socio-demographics (age, age squared, and gender) and resource time-invariant controls (presence of diamond deposits, presence of gold veins, and surface of the gold veins) interacted with the appearance dummy. Standard errors are corrected for a two-way clustering at the regional and country-year level and reported in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.1$.