The Impact of Mobile Phones on Working Conditions in Peru

Abstract: This paper examines whether mobile phones improve job conditions. The literature on the impact of mobile phones on labor markets focuses on the employment levels and shifts from agriculture to the non-agricultural sector. However, Peru is a country where unemployment is not a major concern (remaining below 8% the last two decades), but where a substantial share of workers lack contracts, health insurance, and other basic labor protections. I exploit the aggressive investment in mobile phone infrastructure in 2006 as an exogenous shock and employ a staggered difference-in-differences as my empirical strategy. My indicators of working conditions include having a contract, access to social security (health insurance or pension system), earning income above the poverty line, and complex measures such as informality status, decent work levels, and underemployment. In contrast to the current literature, I find no effects on overall employment or on shifts from agriculture to the non-agricultural sector. However, I find detrimental effects on working conditions, including a decline in private-sector wage employment, lower pension enrollment, fewer labor contracts, and a short-term decline in the share of workers with both contracts and acceptable earnings (first- and second- levels of decent work).

Keywords: Mobile phone infrastructure, technology, innovation, working conditions, efficiency.

1. Introduction

Is the mobile phone a pro-worker technology? Some recent literature indicates that innovations can harm workers (Acemoglu and Restrepo, 2018; Berg et al., 2018, Korinek and Stiglitz, 2019, as cited in Korinek, 2022), but most evidence shows the opposite (Autor, 2001; Kuhn & Mansour, 2014). In a recent paper, Acemoglu indicates that a pro-worker technology expands human capabilities in a way that makes human skills and expertise more valuable (Acemoglu et al., 2026).. In theory, mobile phones are one such innovation, as they increase personal reachability compared to fixed phones, reducing existing frictions and increasing labor market efficiency (Aker & Mbiti, 2010).

The existing literature has documented the effects of mobile phones on labor markets in African and Asia (Aker & Mbiti, 2010; Jensen, 2007; Klonner & Nolen, 2010; Nsabimana & Funjika, 2019), focusing on unemployment and heterogeneous effects in rural labor markets. However, none are examining working conditions. This study contributes new evidence on the impact of mobile phones on working conditions, a topic often overlooked in labor market applications despite its relevance for workers.

Mobile phones increase employment and encourage shifts of labor from agriculture to non-farming sectors in rural labor markets of South Africa and Tanzania (Klonner & Nolen, 2010; Nsabimana & Funjika, 2019). Klonner & Nolen (2010) assess the impact of the rollout of cell-phone antennas on employment in South Africa, finding positive impacts, particularly for women. They also document a shift from agricultural to non-agricultural activities, especially among young men. However, they find no significant change between self-employment and wage-employment. Similarly, Nsabimana & Funjika (2019) find that mobile phone ownership increased the hiring of farm workers, with women benefiting the most. They also observe a shift of labor from agriculture to non-farming private sectors for men under 45, and to the public sector for those over 45.

Peru provides a unique opportunity to study a major supply-side shock followed by the entry of a new competitor, which eventually became one of the country's two dominant firms in the mobile phone market. In contrast, Klonner & Nolen (2010) uses as a treatment variable the rollout of antennas by the main cell phone provider, and they use a geographical instrument to eliminate selection bias in this rollout. Nsabimana & Funjika (2019) use the average number of mobile phones within communities as an instrument for mobile phone ownership to establish causality.

Mobile phone services were introduced in Peru in 1990, but only in metropolitan Lima and exclusively for businesses. A regulatory change in 2005, along with the expansion strategy of the Mexican enterprise America Movil in South America, reshaped the market completely. In 2005, America Movil bought Tim, marking the beginning of a duopoly with the incumbent enterprise of Telefonica del Peru (TdP). By 2006, both firms expanded their mobile phone base stations, extending mobile phone services beyond urban areas and into the country's interior regions.

The main dataset in this study consists of individual-level labor information from repeated cross-sectional data combined with a district-level treatment variable. The treatment variable is the time-varying availability of mobile phone service at the district level between 2004 and 2011. Outcome variables include employment status for the working-age population, as well as employment type, economic sector, labor earnings, and working conditions for the employed population. Given the staggered rollout of mobile phone services, I employ an event-study specification to estimate dynamic effects and test for parallel trends across the labor outcomes.

The results show no shift from agricultural to non-agricultural sectors, a reduction in the share of private-sector wage employees, an increase in the share of unpaid family workers, and a short-term increase in the share of employers. I also find that working conditions quality has declined, as seen in lower pension enrollment, fewer labor contracts, and reduced availability and willingness to work more hours. These trends are associated with a short-term decline in the workers with at least contract and earning above minimum legal wage (first and second level of decent work) and an increase in underemployment. Regarding labor earnings, there was a decline in earnings from primary jobs, particularly among wage employees, but not among non-wage workers.

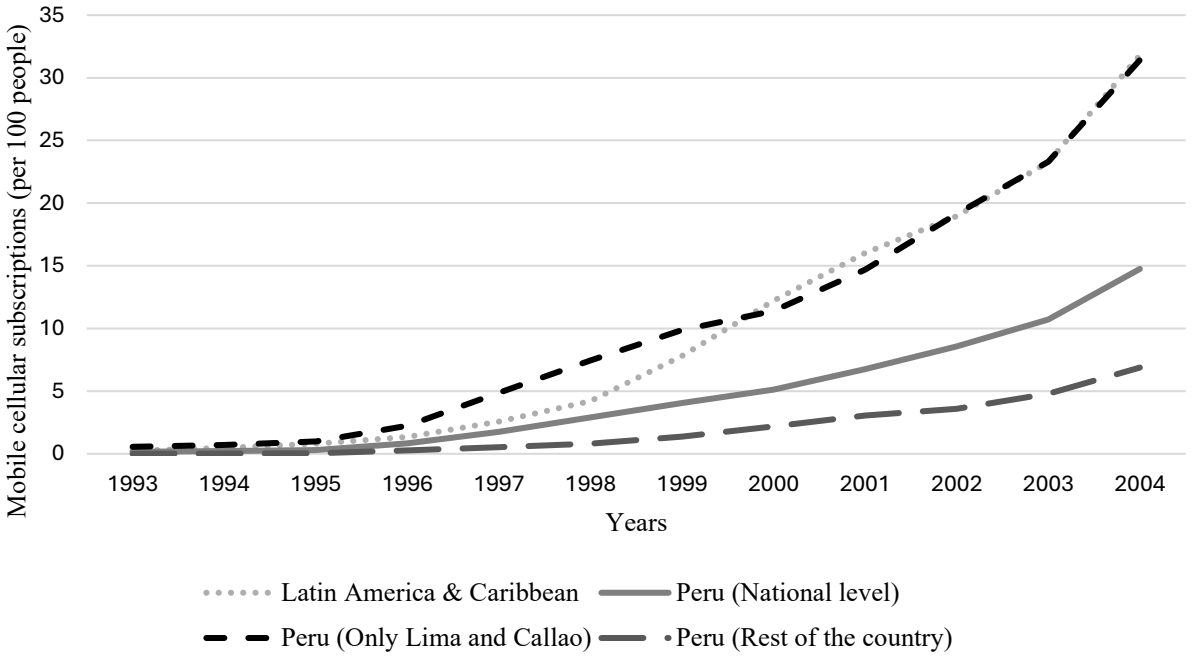
The remainder of the paper is organized as follows. Section 2 describes the mobile phone service market in Peru. Section 3 presents the theoretical framework linking the mobile phone innovation to labor market outcomes. Section 4 describes data and descriptive statistics. Section 5 outlines the empirical strategy and event-study design. Section 6 presents the results on working conditions indicators. The final section concludes.

2. Mobile phone service networks[1] in Peru

The first mobile phone service in Peru was introduced in 1990 by the Peruvian company Tele 2000, which mainly operated in the Metropolitan Lima Area and targeted the corporate sector (El comercio, 2021). In 1994, the Spanish firm Telefonica acquired the two public telephony companies (CPT and ENTEL) and merged to create Telefónica del Perú (TdP). TdP was primarily focused on the fixed-line telephone market but also began to venture into the mobile phone sector (El comercio, 2021; OSIPTEL, 2014).

However, the entry of these two enterprises was not enough to expand the mobile phone market beyond Lima and Callao. Figure *1* shows that only the metropolitan area of Lima and Callao displays a similar trend to the Latin American region, while the rest of the country lags significantly behind. In 2004, only 5 out of every 100 people outside Lima and Callao had a mobile cellular subscription, compared to rates five times higher in Lima and Callao or the Latin America average.

Figure 1. Mobile cellular subscriptions (per 100 people), by region (1993-2004)



Own elaboration (MTC Secretariat of Communications, 2004; World Bank, 2025)

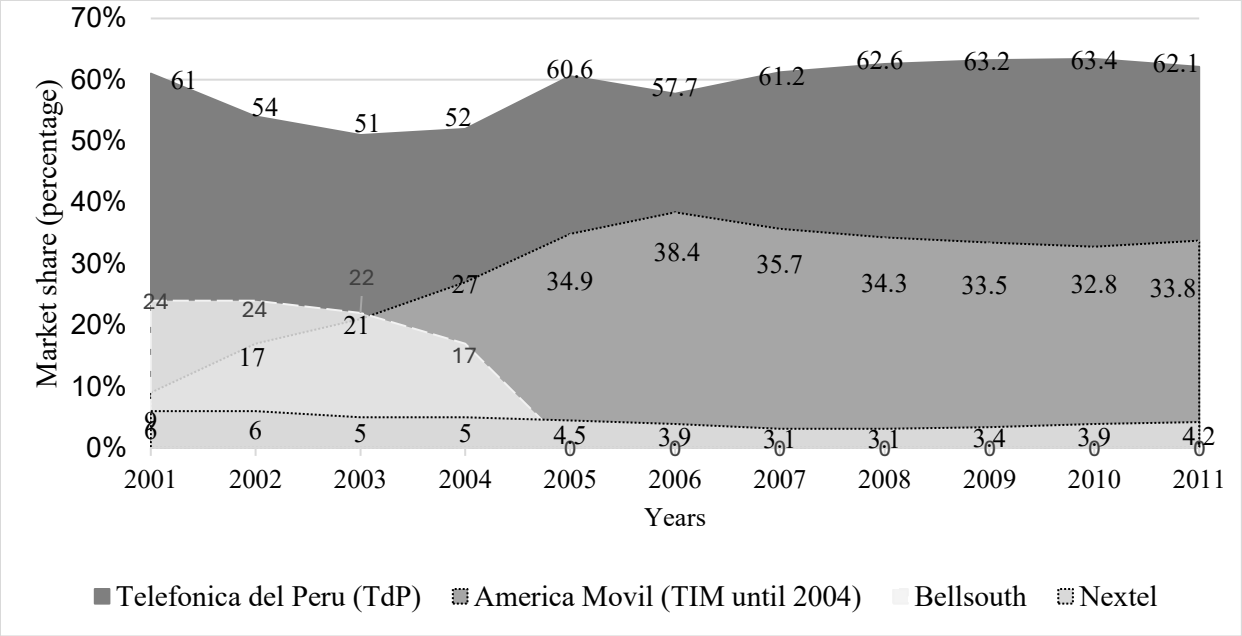
[1] Mobile phone services networks include mobile phones, personal communication systems (PCS), and multiple automatic selection channels trunking.

There were two regulatory changes in mobile phone services networks that helped stimulate the market. In 1996, the responsibility for paying for calls between mobiles and fixed lines was shifted to the calling party; previously, the mobile phone user bore the cost regardless of who initiated the call (OSIPTEL, 2014). One year later, Bellsouth acquired Tele 2000 and the following year it won the concession to provide mobile services in the interior regions of Peru (El comercio, 2015; OSIPTEL, 2014). The Italian company TIM won the auction to operate mobile service networks in 2000 (OSIPTEL, 2014). Nextel entered the mobile phone market in 1998, but its operations were mainly focused on corporate clients (Infobae, 2023).

The second change occurred in 2005, when telecom supervisor (OSIPTEL) intervened to set maximum interconnection charges between operators in mobile service networks. For example, the interconnection charge for a call from a TIM cellphone to a TdP user was US$ 0.70 per minute, while charges within the same operator cost US$ 0.4 (MTC Secretariat of Communications, 2004). Reducing this cost encouraged fair competition because it allowed operators to reach their optimal scale size, which was especially important for new entrants (OSIPTEL, 2014). In that same year, TdP acquired Bellsouth but had to return one of the mobile phone bands to prevent excessive market concentration before the merger (Peruvian government portal, 2006e).

America Movil showed a tendency to expand in Latin America by acquiring smaller enterprises, with the purchase of TIM, serving as its entry to the Peruvian Market in August of 2005 (Latin Spots, 2005; Ophelimos, 2005; Redes Telecom, 2005). América Movil considered Peru the most promising country in the mobile phone market of the region due to its low penetration compared to other Latin American countries (Peruvian government portal, 2006a). In June 2006, America Movil became the operator with the widest coverage across the regions of the country (Peruvian government portal, 2006c). At the same time, TdP sought to broaden its offerings, resulting in a duopoly with America Movil that will remain for the analyzed period. Figure *2* displays the market share of TdP and America Movil for the period between 2001 and 2011, and how the duopoly started in 2005, after the TIM and Bellsouth mergers.

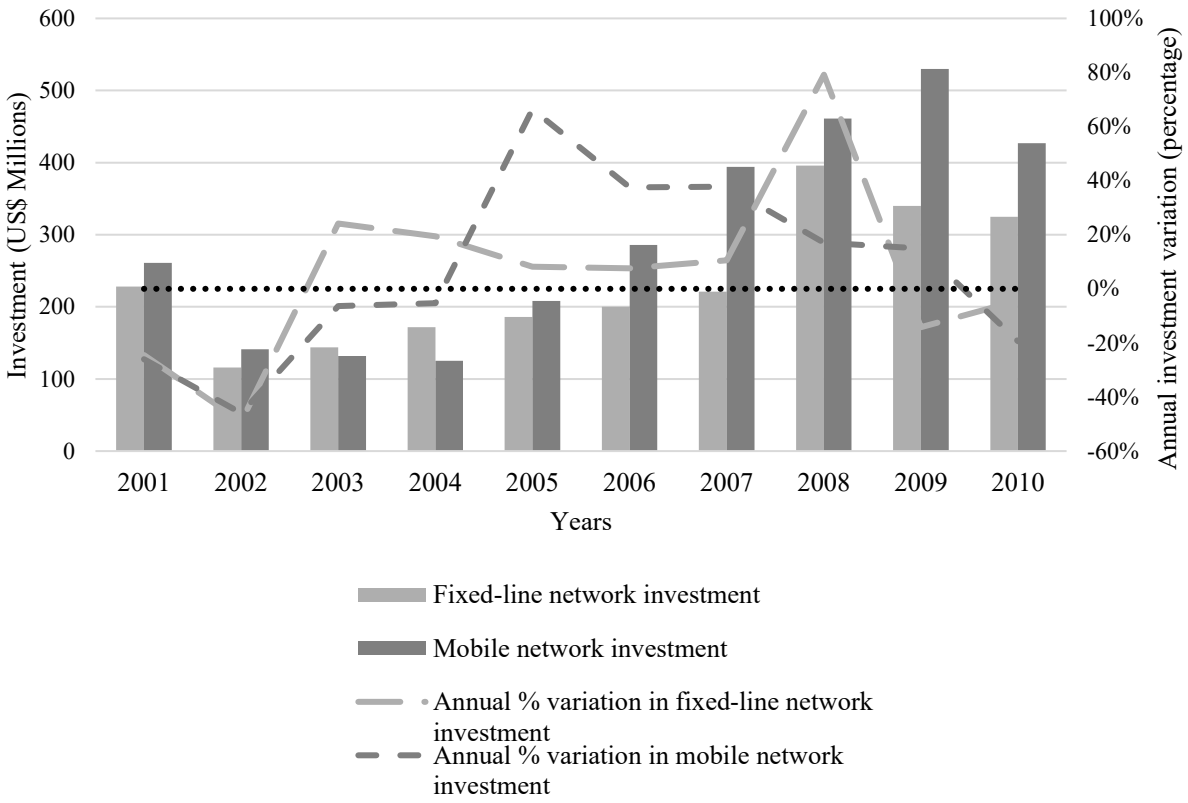
Figure 2. Evolution of the market share (percentage) of mobile services by company



Notes: The information comes from the 2011 Annual Report of the Secretariat of Communications (MTC Secretariat of Communications, 2011).

The entry of America Movil into the Peruvian mobile phone industry represented a supply shock. In 2006, Carlos Slim and the company's CEO, Humberto Chavez, announced a strong investment commitment, starting with an initial investment of USS 100 million dollars to expand the capacity of mobile networks (Peruvian government portal, 2006b, 2006d). Figure *3* illustrates investment trends across mobile phone services and other telecommunication services (fixed phone and internet) in the Peru from 2001 to 2010. Between 2004 and 2009, investment in mobile networks rose substantially, peaking in 2005. Fixed-line networks, by contrast, showed a single increase in 2008, which then declined in the following years.

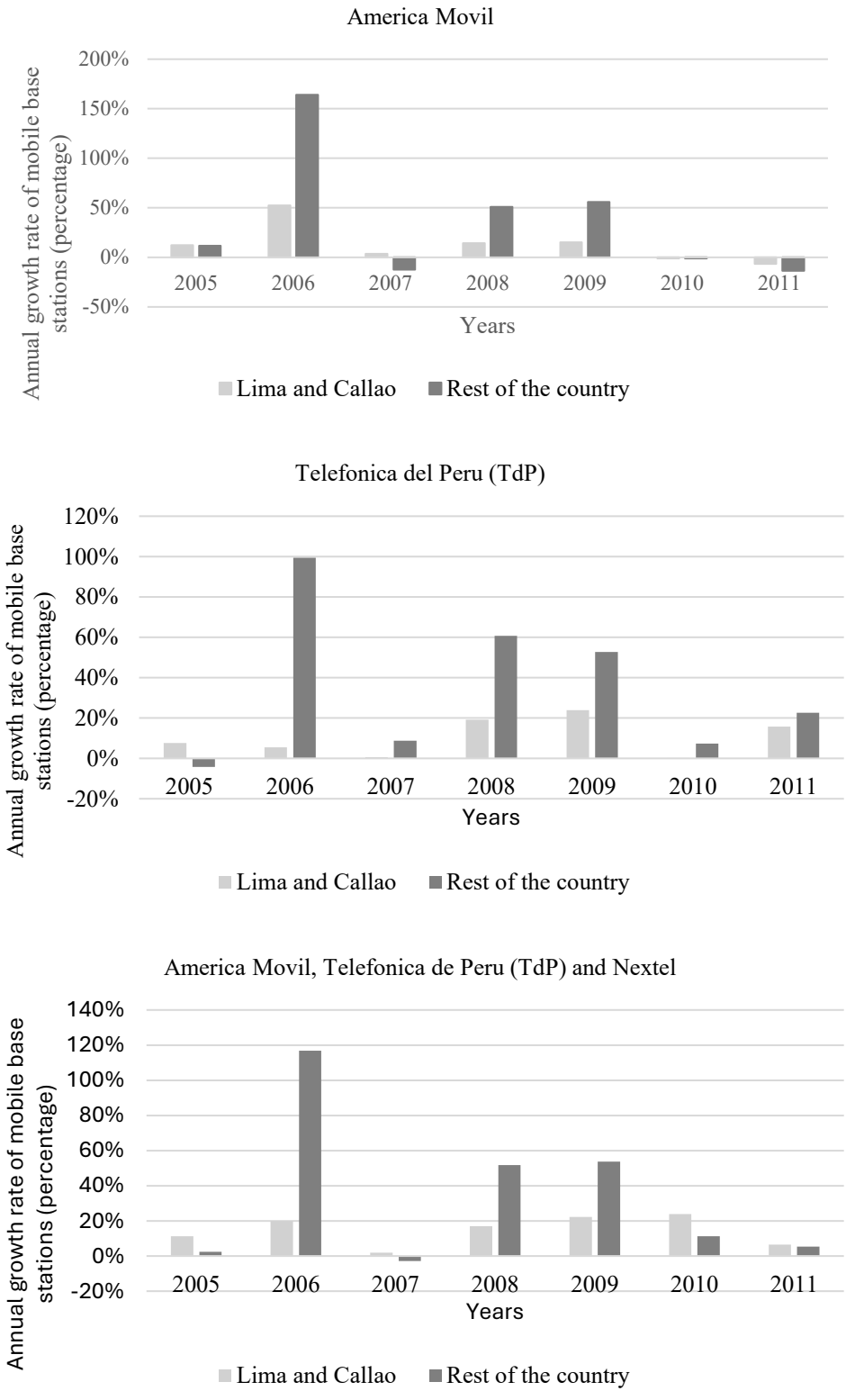
Figure 3. Telecommunication Investment (US$ Millions) and Annual Percentage Change, by Network Type (2001-2010)



Source: Telecom service providers (OSIPTEL, 2012). From 2002 to 2008, referred to fixed-line networks as fixed-line telephone services, and mobile networks were referred to as mobile phone services, reporting similar numbers for this period (OSIPTEL, 2008).

These investments were also linked to the increase in mobile phone base stations across the country during these years. Figure 4 shows that America Movil expanded mobile phone base station infrastructure across regions in the mobile phone market. Similarly, TdP invested in mobile phone base stations across regions during the same period. Overall, mobile phone operators focused their investments on increasing the necessary infrastructure, particularly in the regions outside Lima and Callao.

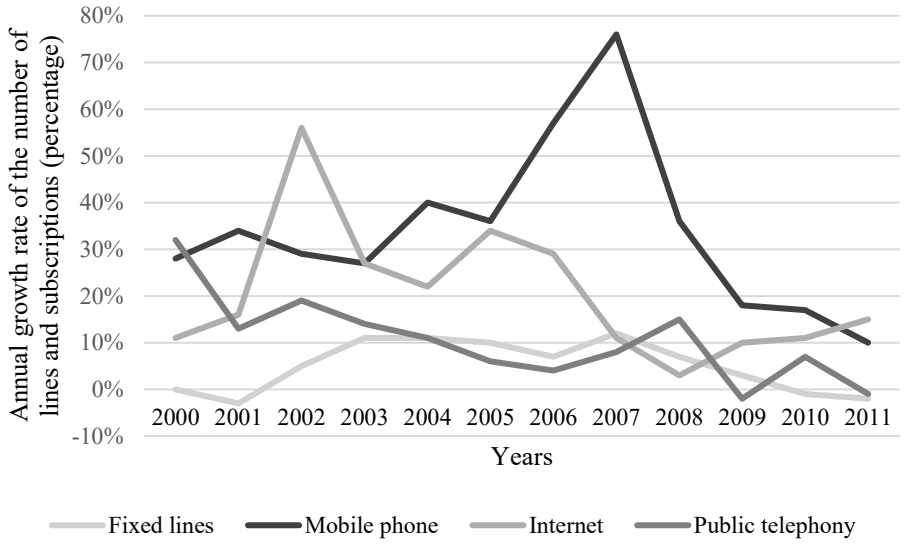
Figure 4. Annual growth of the mobile base stations by company and region (2005-2011)



Own elaboration, based on the 2004-2011 reports of the MTC Secretariat of Communications. Notes: Lima is the region and not only the metropolitan area.

Compared with other telecommunication services, mobile phones experienced a shift around 2006, while the other services did not. Figure *5* shows a sharp increase in the number of mobile phone lines and subscriptions during 2006 and 2007. Public telephony shows a declining trend, while internet subscription peaked in 2002 and had a smaller peak in 2005 and 2006. Finally, household fixed-line telephones display a very stable trend throughout the entire period.

Figure 5. Annual increase (percentage) of the number of lines and subscriptions by type of telecommunication services, 2000-2011



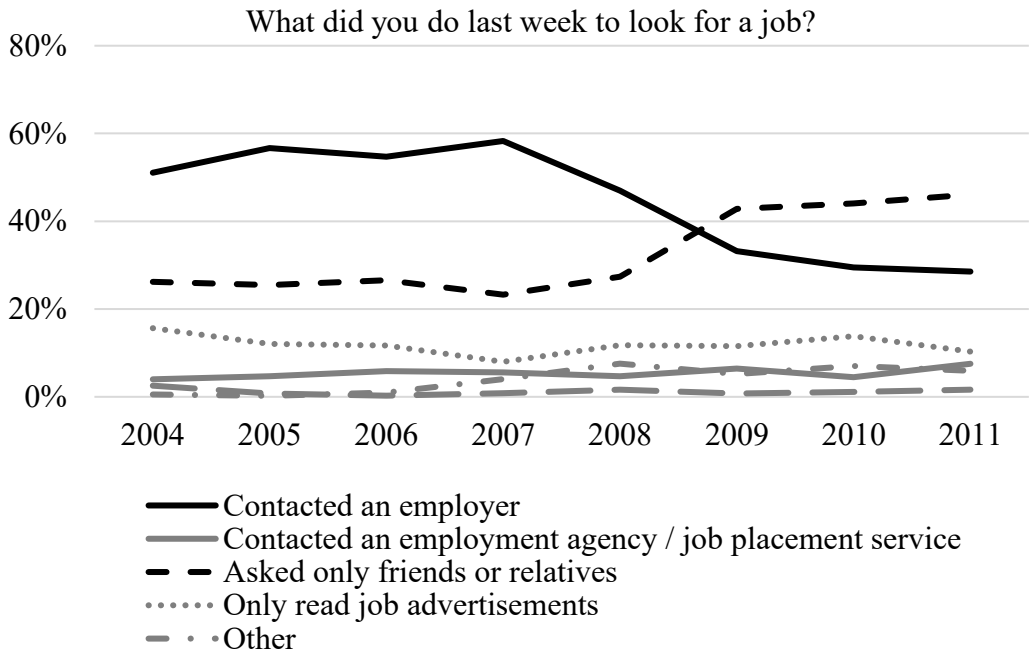
3. Theoretical framework

Complete information is a fundamental assumption underlying the "First Fundamental Theorem of Welfare Economics" and the "Law of one Price" (Jensen, 2007). In the presence of information asymmetry, resulting allocations become suboptimal and price differences between any two markets create arbitrage opportunities (Aker et al., 2011). Thus, the results could cause waste and price dispersion theoretically.

The resulting "waste" from information friction in the labor market is reflected in worker misallocations. This waste is manifested in people who want to work but cannot (unemployment), individuals who desire to work more than they currently do (underemployment), or poor matches between jobs and workers (skill mismatches). Mobile phone technology reduces search costs for better job opportunities, leading to better worker allocation and lower labor earnings dispersion (Aker & Mbiti, 2010).

The expansion of mobile phone infrastructure helps reduce information asymmetry on both sides of the labor market: firms and workers. Hiring through social networks-based referrals is a common practice (Breza & Kaur, 2025), and mobile phones, which can be carried at all times (unlike landlines), facilitate continuous communication. As a result, workers can stay in touch with contacts outside their region, while firms can more easily reach potential employees. In Peru, job search patterns shifted during the study period. Figure 6 shows that, since 2008, workers have increasingly relied on friends and family rather than direct contact with employers.

Figure 6. Contact type to look for a job, 2004-2011



Source: ENAHO (2004-2011)

Better communication benefits not only the interaction between workers and firms but also improves communication between firms and their suppliers. This can enhance production

processes, such as better supply chain management, a reduction in stock-outs and production interruptions, and the ability to engage in additional activities, all of which increase production and reduce waste (Aker & Mbiti, 2010). Mobile phones can be viewed as an integral input in the factors of production (Nsabimana & Funjika, 2019) or as a technological innovation that increases labor productivity.

For the period analyzed (2004-2011), the main impact of mobile phone infrastructure likely occurred through facilitating communication within social networks for both workers and firms, and to lesser extent, through the creation of new jobs to meet the demand for mobile-related services (Aker & Mbiti, 2010). However, the potential for mobile phone–based applications to improve the delivery of financial, agricultural, health, or educational services (Aker & Mbiti, 2010) was likely limited during this period, as these applications depend on internet access through mobile phones, which was probably still low in Peru in the analyzed period.[2]

4. Data and descriptive statistics

My mobile phone infrastructure variable, or my treatment variable, is a time-varying binary indicator for having mobile phone service at the district level over the period of 2004 to 2011. My main source for this is the MTC Secretariat of Communications (now defunct), which published quarterly reports on public telecommunications services statistics for the same period. These reports included statistics at the national level as well as at district-level in Peru[3], covering internet, mobile phone, and landline, representing most of the relevant communication technologies in the country.

Using this information, the 2007 INEI district shapefile, and district codes from the 2007 Peruvian Population Census, I construct a treatment variable that considers a district as treated if mobile phone service is available (Appendix 1). Table 1 shows the number of treated districts by year during the 2004-2011 period, reflecting a sharp increase between 2005 and 2006, where the infrastructure expansion began.

[2] In 2011, only 36.5% of the population had internet access (INEI, 2011), and by 2016, just 50% of those users accessed the internet through their mobile phones (BBVA, 2017).
[3] Peru is divided into 3 administrative levels: regions or *departamentos*, provinces, and districts.

Table 1. Number of treated districts, by year

First year with Mobile Phone Service	Treated Districts[4] (Marginal)	Treated districts (Cumulative)
2004 or before	399	399
2005	11	410
2006	560	970
2007	259	1229
2008	194	1423
2009	61	1484
2010	102	1586
2011	23	1609
Never treated*	225	1834

Note: Never treated refers only to the districts that were not treated in the analyzed period (2004-2011). For practical purposes, I will use this term to refer to that group.

For the outcomes, I used the nationally representative household survey ENAHO, which is widely used in applied research in Peru (Dell, 2010; Aragón & Rud, 2013; Bellemare et al., 2018; and Cisneros-Acevedo, 2022). Conducted continuously since 1997 by the National Institute of Statistics (INEI), ENAHO follows a probabilistic and multi-stage sampling design with two strata[5] (rural and urban areas) and provides national and regional inference at the 95% confidence level, reflecting the figures of the 2007 Population Census. I primarily rely on the labor module of ENAHO, and restrict the sample to individuals aged 14 to 65, corresponding to the working-age population in Peru. In 2004, ENAHO's survey design included 21,919 households (INEI, 2004), though the dataset contains 19,502 households and 59,994 individuals aged 15-64. I pool repeated cross-sections from the ENAHO survey for the period 2004 to 2011 to construct an individual-

[4] There are 29 districts (1.5% of all districts) that experience a treatment turn-off, so I recoded these observations as zero, treating them as never treated. I will include the 29 districts that experience a treatment turn-off as treated from the first year they are reported as treated as a future sensitivity analysis.

5 In urban areas, sampling follows three stages: communities with over 2,000 inhabitants serve as primary units, subdivided by INEI into clusters averaging 80 dwellings (2004–2006) and 120 dwellings (2007–2011); the dwelling is the third-stage unit and may include multiple households. Rural areas follow a similar design, though the number of stages may be reduced to two in smaller communities (500–2,000 inhabitants).

level dataset of non-panel individuals[6] aged 15-64. Table 2 presents the distribution of individuals across the treated and control districts in the 2004-2011 pooled ENAHO sample.

Table 2. Sample sizes (individuals aged 14–65s) in the 2004–2011 pooled ENAHO sample

Year	Control: Never treated	Control: Not yet treated	Treated
2004	2,153	19,582	33,159
2005	1,872	15,630	23,693
2006	2,035	6,577	34575
2007	2,085	4,437	52,906
2008	2,097	2,159	53,424
2009	2,222	1,773	54,453
2010	2,167	322	54,767
2011	2,454	0	62,537
Total	17,085	50,480	369,514

Source: ENAHO (2004-2011)
Notes: 'Never treated' group is the districts that are not treated for the analyzed period (2004-2011)

My individual-level outcomes comprise key labor variables and working conditions. For the individual-level outcomes, I construct dummy variables for each category of employment status, employment type, and economic sector. Regarding the labor earnings, I focus on fourth monthly measures: earnings from the primary non-wage job, earnings from the primary job, monetary earnings from the primary job, and total earnings from the primary job. ENAHO provides annualized and deflation-adjusted versions[7] of these variables, which I divide by twelve to obtain monthly values (expressed in 2009 Peruvian Nuevos Soles).

In terms of working conditions, I employ both dummy variables and composite indicators. These include health insurance enrollment, pension system enrollment, earning above the legal minimum or minimum consumption basket (poverty threshold), contract status, working beyond than statutory maximum of 48 hours per week, willingness ability to work additional hours, informality, underemployment, and decent work. Further details of construction of all the variables are

[6] Before 2007, ENAHO was presented as a single database with cross-sectional (non-panel) and panel sample. For the years 2005 and 2006, I excluded the panel sample by filtering out households that reported having been interviewed the previous year, since my analysis focuses on the cross-sectional sample.
[7] After annualization, INEI applied a regional consumer price index (CPI)-based adjustment to convert all nominal values to real 2009 prices (INEI, 2013). I use the second version of the labor income variables.

provided in Appendix *2*. Table *3* summarizes these indicators, along with their mean in the first and last years of the analyzed period (2004-2011). The results indicates improvements in working conditions, a shift from agricultural to non-agricultural sector, and a movement from private wage employment to private non-wage employment between 2004 and 2011.

Table 3. Mean values of individual labor outcomes in 2004 and 2011

Category	Variable	Mean in 2004	Mean in 2011
Employment status	Employed	71.20	73.98
	Unemployed	3.43	2.70
	First-time unemployed	0.64	0.58
	Unemployed with prior work experience	2.79	2.12
	Inactive	25.37	23.32
Employment type	Public wage employee	8.25	9.28
	Private wage employee	26.03	29.81
	Private non-wage employee	65.72	60.91
	Employer	5.14	5.46
	Self-employee	35.75	36.57
	Unpaid family worker	21.76	16.59
	Domestic worker	3.07	2.28
Working conditions (dummy indicators)	Earning above minimum wage	27.22	35.96
	Earning above poverty threshold	19.59	41.34
	With contract	16.94	26.77
	Working more than 48 hours per week	60.80	61.07
	Enrolled in a pension system	8.31	26.22

Category	Variable	Mean in 2004	Mean in 2011
	Enrolled in a health insurance	25.14	63.11
	Want and can work more	20.91	19.30
Working conditions (composite indicators)	Informal workers	85.06	79.95
	Higher levels of decent work (basic rights ensured)	6.78	17.05
	Lowest level of Decent Work (deprived of rights)	20.25	7.27
	Underemployed by hours	7.52	6.64
	Underemployed by income	73.77	53.28
Economic sector	Workers in agriculture	43.29	37.70
	Workers in manufacturing	6.75	6.76
	Workers in mining	1.15	1.78
	Workers in other non-agricultural important sectors	30.71	33.51
	Workers in construction	3.41	5.61
	Workers in sales	19.51	18.68
	Workers in personnel services	7.15	8.36
	Workers in other sectors	18.10	20.25
Monthly labor earnings (expressed in 2009 Peruvian Nuevos Soles)	Earnings from primary job	509.82	855.52
	Monetary earnings from the primary job	473.34	807.70
	Earnings from a primary wage job	639.72	1003.73
	Earnings from a primary non-wage job	392.95	705.43

Source: ENAHO 2004 and 2011

As with most surveys, the main limitation is the presence of missing observations across variables, particularly in labor income variables. The 2004–2011 pooled cross-sectional ENAHO includes 463,813 individuals distributed across years and treatment groups (Table 2). There are 1,231 missing values (0.3%) for the variable indicating activity status (employed, unemployed, and inactive). Among variables related to employment outcomes, whose universe is the employed individuals (318,275), there are no missing observations, except for informal employment which has 6,020 missing values (2%). Labor income variables present the highest rate of missing data: income from primary job (21.7%), monetary income from primary job (24.7%), income from primary wage job (3.5%), and income from primary non-wage job (36.9%).

5. Empirical framework

5.1. Estimation strategy

I use an event-study using the interaction-weighted estimator of Sun and Abraham (Sun & Abraham, 2021), implemented via *sunab* in *fixest* . This method corrects the bias that arises in traditional TWFE event-studies with staggered treatment timing (Goodman-Bacon, 2021), by comparing each cohort only to appropriate not-yet treated units. Then, the standard TWFE equation becomes, in SA form:

$$y_{ist} = \alpha_s + \alpha_t + \sum_{g} \sum_{\substack{j=-7 \\ j \neq -1}}^{6} \gamma_{g,j} 1\{E_s = g\} 1\{t - E_s = j\} + \alpha_{rdt} + u_{ist}$$

On the left-hand side, y_{ist} is the outcome and represents a characteristic about the labor market allocation (a dummy variable) for the person *i* in the district *s* in the calendar time *t*. The index t denotes calendar time, and the index *j* represents all the periods from when the event happened or "event-time". The event-date (E_s) is the year when the mobile phone coverage if first introduced in the district *s* in this context. The event-time *j* ranges from -7 to 6. Typically, the first lead (*j*=-1) is excluded as a normalization.

On the right-hand side, $1\{t - E_s = j\}$ is a dummy indicator equal to 1 for the district *s* in a calendar period that is j lags (*j*>0) or leads (*j*<0) from the event-date. Likewise, $1\{E_s = g\}$ is a dummy indicator for the districts that begin their mobile phone service (treatment) in year g, identifying

the *cohort* to each district belong, and $\gamma_{g,j}$ is the event-time effect j for cohort g. District and calendar time fixed effects are denoted as α_s and α_t, respectively. I include as additional fixed effects (α_{rdt}) the interaction between the administrative region or *departamento* (first administrative level) with year and natural region (urban coast, rural coast, urban highlands, rural highlands, urban rainforest, rural rainforest, and metropolitan area of lima). Finally, standard errors are clustered at the district level, as the treatment occurred at that level.

Then, the interaction-weighted estimator of Sun and Abraham (Sun & Abraham, 2021) is calculated for each event-time *j,* using weights $w_{g,j}$, based on how much each cohort contributes at that event time:

$$\hat{\beta}_j = \sum_g w_{g,j}\gamma_{g,j}$$

The control group consists solely of not-yet-treated districts, meaning that never-treated districts are excluded. For the 2004-2011 period, I assume that never-treated districts differs substantially from the treated group.

5.2. Identification strategy

I test the parallel trends assumptions for both type of outcomes. Using the main specifications, I use the lead coefficients (j<0) to assess the parallel trends hypothesis. I use t-test to evaluate individual coefficients and a Wald test to assess the joint null hypothesis that all the lead coefficients are jointly insignificant (all j<0, except for j=-1). I use a clustered error structure at the district level for both tests.

$$H_0: \beta_j < 0$$

The results for parallel trend tests for employment outcomes are shown in Appendix 3. According to Appendix *3*, the variables that do not satisfy the parallel trend assumption include employment, unemployment, and unemployment with prior experience; private non-wage employment; income above the poverty threshold; having health insurance; being an informal worker; being in the highest level of decent work (level 1) or the lowest level (level 5); working in personnel services; and most of the log income variables. The remaining variables failed at the top two out of the seven

parallel trend tests (six individual and one joint tests). Then, I focus the discussion on employment type, working conditions, economic sector, and labor income, excluding the variables that did not pass the parallel trend tests mentioned earlier.

6. Results

There has been a reduction in private-sector wage employment (Table *4*), but no shift from the agricultural to the non-agricultural sector (Table *5*). Working conditions have declined, as reflected in lower enrollment in pension systems, fewer labor contracts, and reduced availability and willingness to work more hours (Table 6). These trends may be associated with a short-term decrease in decent work (levels 1 and 2) and an increase in underemployment. Regarding labor income, Table *7* shows that there was a decline in income from primary jobs, particularly among wage employees, but not among non-wage workers.

Table 4. Dynamic effects on employment type outcomes

	J=+1	J=+2	J=+3	J=+4	J=+5	J=+6
Public wage employee						
Mobile phone service	-0.003	0.003	0.004	0.004	0.005	-0.015
	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)	(0.033)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.06	0.06	0.06	0.06	0.06	0.06
Private wage employee						
Mobile phone service	-0.020**	-0.026**	-0.038***	-0.044***	-0.034***	0.021
	(0.009)	(0.010)	(0.011)	(0.012)	(0.012)	(0.045)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.09	0.09	0.09	0.09	0.09	0.09
Employer						

Mobile phone service	0.001	0.009**	0.005	0.003	-0.005	-0.071***
	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.022)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.02	0.02	0.02	0.02	0.02	0.02
Self-employee						
Mobile phone service	0.015**	0.004	0.009	0.010	0.015	0.044
	(0.008)	(0.008)	(0.009)	(0.010)	(0.011)	(0.028)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.03	0.03	0.03	0.03	0.03	0.03
Unpaid family worker						
Mobile phone service	0.010	0.012	0.020*	0.028**	0.022*	0.011
	(0.009)	(0.010)	(0.010)	(0.012)	(0.013)	(0.070)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.14	0.14	0.14	0.14	0.14	0.14
Domestic worker						
Mobile phone service	-0.003	-0.002	-0.000	-0.000	-0.003	0.009
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.007)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.02	0.02	0.02	0.02	0.02	0.02

Notes: The cells show the coefficients along with their significance levels: *** for 1%, ** for 5%, and * for 10%.

Table 5. Dynamic effects on economic sector outcomes

	J=+1	J=+2	J=+3	J=+4	J=+5	J=+6
Workers in agriculture						

Mobile phone service	-0.002	-0.003	-0.000	0.003	-0.003	0.037
	(0.014)	(0.016)	(0.016)	(0.018)	(0.019)	(0.084)
N	276,743	276,743	276,743	276,743	276,743	276,743
R2	0.52	0.52	0.52	0.52	0.52	0.52
Workers in manufacture						
Mobile phone service	0.005	0.009	0.002	0.008	0.015**	-0.007
	(0.005)	(0.006)	(0.006)	(0.007)	(0.007)	(0.039)
N	276,743	276,743	276,743	276,743	276,743	276,743
R2	0.05	0.05	0.05	0.05	0.05	0.05
Workers in mining						
Mobile phone service	-0.000	0.000	-0.002	-0.002	-0.001	0.013
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.015)
N	276,743	276,743	276,743	276,743	276,743	276,743
R2	0.15	0.15	0.15	0.15	0.15	0.15
Workers in other non-agriculture important sectors						
Mobile phone service	0.008	0.012	0.016	0.006	0.004	-0.015
	(0.011)	(0.012)	(0.012)	(0.014)	(0.015)	(0.042)
N	276,743	276,743	276,743	276,743	276,743	276,743
R2	0.16	0.16	0.16	0.16	0.16	0.16

Notes: The cells show the coefficients along with their significance levels: *** for 1%, ** for 5%, and * for 10%.

Table 6. Dynamic effects on working conditions outcomes

	J=+1	J=+2	J=+3	J=+4	J=+5	J=+6
Earning income above minimum wage						
Mobile phone service	-0.010	-0.005	-0.019*	-0.018	-0.008	-0.058
	(0.008)	(0.009)	(0.010)	(0.011)	(0.013)	(0.044)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.18	0.18	0.18	0.18	0.18	0.18
With contract Mobile phone service	-0.014	-0.012	-0.020**	-0.021*	-0.013	-0.014
	(0.009)	(0.009)	(0.009)	(0.012)	(0.014)	(0.035)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.16	0.16	0.16	0.16	0.16	0.16
Working more than 48 hours per week						
Mobile phone service	0.006	0.002	0.016	0.033**	0.016	0.092
	(0.011)	(0.012)	(0.012)	(0.014)	(0.015)	(0.069)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.07	0.07	0.07	0.07	0.07	0.07
Enrolled in a pension system						
Mobile phone service	-0.019**	-0.022***	-0.030***	-0.033***	-0.021*	-0.016
	(0.008)	(0.008)	(0.009)	(0.010)	(0.012)	(0.044)
N	304,434	304,434	304,434	304,434	304,434	304,434
R2	0.18	0.18	0.18	0.18	0.18	0.18

Want and can work more						
Mobile phone service	0.021*	0.029***	0.042***	0.042***	0.036**	-0.063**
	(0.011)	(0.011)	(0.011)	(0.013)	(0.014)	(0.028)
N	304,428	304,428	304,428	304,428	304,428	304,428
R2	0.09	0.09	0.09	0.09	0.09	0.09
Decent workers (1st and 2nd levels)						
Mobile phone service	-0.007	-0.011	-0.018**	-0.011	-0.006	-0.014
	(0.006)	(0.007)	(0.007)	(0.008)	(0.010)	(0.028)
N	304,435	304,435	304,435	304,435	304,435	304,435
R2	0.12	0.12	0.12	0.12	0.12	0.12
Underemployed by hours						
Mobile phone service	-0.002	0.006	0.009	0.012*	-0.001	0.003
	(0.006)	(0.006)	(0.006)	(0.007)	(0.008)	(0.020)
N	304,431	304,431	304,431	304,431	304,431	304,431
R2	0.04	0.04	0.04	0.04	0.04	0.04
Underemployed by income						
Mobile phone service	0.014	-0.001	0.010	0.010	0.014	0.090**
	(0.010)	(0.011)	(0.012)	(0.013)	(0.014)	(0.038)
N	304,431	304,431	304,431	304,431	304,431	304,431
R2	0.16	0.16	0.16	0.16	0.16	0.16

Notes: The cells show the coefficients along with their significance levels: *** for 1%, ** for 5%, and * for 10%.

Table 7. Dynamic effects on income labor outcomes

	J=+1	J=+2	J=+3	J=+4	J=+5	J=+6
Income from primary job						
Mobile phone service	-24.652	-40.132*	-43.793*	-29.601	-32.261	-56.051
	(19.659)	(21.034)	(23.181)	(27.143)	(42.811)	(126.424)
N	240,455	240,455	240,455	240,455	240,455	240,455
R2	0.13	0.13	0.13	0.13	0.13	0.13
Monetary income from primary job						
Mobile phone service	-22.031	-43.778**	-44.792*	-30.196	-30.002	-76.371
	(20.274)	(21.121)	(23.609)	(27.506)	(43.914)	(102.467)
N	231,497	231,497	231,497	231,497	231,497	231,497
R2	0.12	0.12	0.12	0.12	0.12	0.12
Income from primary wage job						
Mobile phone service	-29.916	-53.340**	-58.360**	-68.407**	-55.479	-22.897
	(24.017)	(24.823)	(27.283)	(29.584)	(36.905)	(144.570)
N	120,202	120,202	120,202	120,202	120,202	120,202
R2	0.17	0.17	0.17	0.17	0.17	0.17
Income from primary non-wage job						
Mobile phone service	-12.934	-11.865	-4.503	27.262	4.242	-37.946
	(21.156)	(23.973)	(27.361)	(33.804)	(56.725)	(115.248)
N	120,238	120,238	120,238	120,238	120,238	120,238

R2	0.11	0.11	0.11	0.11	0.11	0.11

7. Conclusions

Mobile phones are an innovation that increases the amount of information compared to the previous technology of fixed landline phones. Jensen (2007) states that information in a market should reduce inefficiency and price dispersion. The existing literature on the effects on the labor market has focused on unemployment and shifts from the agricultural sector to the non-agricultural sector, but none have examined working conditions. Using the entry of America Movil and the infrastructure expansion in 2006, I evaluate the impact of mobile phone rollout, through the mobile phone service at the district level, on working conditions in Peru.

The results for Peru differ from those documented for African countries. While previous studies have found increases in employment (Klonner & Nolen, 2010) or shifts from agricultural to non-agricultural sectors in rural labor markets in Africa (Klonner & Nolen, 2010; Nsabimana & Funjika, 2019), I find no impact on these outcomes in the rural and urban labor markets of Peru. However, there has been a reduction in private-sector wage employment, and some indications of working conditions have declined, as reflected in lower enrollment in pension systems, fewer labor contracts, and reduced availability and willingness to work more hours. These trends are consistent with a short-term decline in decent work (levels 1 and 2), an increase in underemployment, and a reduction in earnings from primary jobs, particularly among wage employees, but not among non-wage workers.

The results help explain the contextual differences between African countries and Peru. Peru has historically been characterized by low unemployment rate, which limits the scope for detecting employment effects. While unemployment were 16% in South Africa in 1995 (Klonner & Nolen, 2010) and 12% in Tanzania in 2008 (Nsabimana & Funjika, 2019), Peru's unemployment rate was around 4% in 2006. In this context, the evidence of deteriorating working conditions with no effects on unemployment suggests that technological expansion does not automatically translate into improvements in working conditions. Complementary policies may be necessary to ensure that technological progress leads to better labor market outcomes.

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Appendix and additional tables

Appendix 1. Construction of the treatment variable

My main source is the district-level maps of mobile phone service published in the quarterly reports of the MTC Secretariat of Communications, using the fourth-quarter reports of each year. I chose the fourth quarter reports instead of other quarters because the labor outcomes are measured annually, and the maps are not always in the other quarterly reports. The only exception is the year 2011, for which the fourth-quarter report is not available or does not exist.

Moreover, this is the only source that provides information on mobile phone service at the district-level for the analyzed period[8]. However, these maps are only available in PDF format and are not part of any table or dataset suitable for direct processing.

Using the 2007 district-level shapefile from the National Institute of Statistics (INEI), I added yearly variables indicating whether each district had mobile phone service for each year of the analyzed period (2004-2011). I was able to recover only 1815 districts from the maps and the shapefile.

Then, I cross- validated with the districts listed in the 2007 Peruvian Population and Housing Census, through which I obtained the official number of 1834 districts (INEI, 2008). This Census was also conducted by INEI and considered the districts of Mazamari and Pangoa (Junín) as a single integrated district, while it was unable to survey Carmen Alto (Ayacucho) because local authorities refused to cooperate (INEI, 2008b). Conversely, nineteen districts were in the 2007 Census but not in the shapefile, so they were included.

I incorporated these 19 districts using original maps from the internet and information from the primary and secondary administrative divisions of the Census to locate them in the fourth-quarter reports. When identifiable, I manually edited the yearly variables of mobile phone availability. The final shapefile includes information on mobile phone availability for all 1,834 districts during the 2004-2011 period.

[8] I reached out to Supervisory Agency for Private Investment in Telecommunications in Peru (OSIPTEL) and the MTC for more information. OSIPTEL's response was that they didn't have information prior to 2015, and the MTC had only data for 2010–2011.

Appendix 2. Construction of labor outcomes

To construct most indicators, I rely on the activity status (r3), which has three categories: employed, unemployed and inactive.

I create a variable (pre_r3) that indicates whether the individual was working last week or had a job or own a business to resume soon (pre_r3 =1), or otherwise (pre_r3=2). To define this variable, I identify individuals who (i) worked at least one hour to generate income last week (question p504), (ii) worked last week (question p501), (iii) had a permanent job (question p502), or (iv) had a business to resume soon (question p503).

Based on these 2 categories, I define the activity status as follows:

- Employed: Includes those categorized as pre_r3=1, who are employers, self-employee, wage employee, or domestic worker. It also includes unpaid family workers or others who worked at least 15 hours during the last week.
- Unemployed: Includes individuals who take action to find a job last week (p545=1 and p550 =1 to 5), or those who did not take action to find a job (p545=2), but were doing something related to employment (p546=1 or 2), or they did not take action to find a job (p545=2), were doing activities unrelated to employment (p546=3 to 8), but wanted to work (p547=1), were available to work (p548=1), and either had already found a job (p549=10) or were looking for a job (p549=11). This applies to all individuals who were not working (pre_r3 = 2), or unpaid family workers and others who worked less than 15 hours despite being categorized as working the previous week (pre_r3 = 1).

  Within the unemployed category, we can distinguish two types: those with experience and those without experience. This distinction is made using variable **p552**, which asks, "Have you worked before?" Individuals who answer *yes* are categorized as **unemployed with prior experience**, while those who answer *no* are categorized as **first-time unemployed**.
- Inactive: Includes individuals who did not take action to find a job last week (p545=1 and p550 =6), or those who did not look for work (p545=2) but were engaged in non-work-related activities such as studying or housework (p546=3 to 8). Even if they wanted to work and were able to work (p547=1 and p548=1), they are considered inactive if they did not look for a job for other reasons (p549=1 to 9), or did not look for a job (p549=11 and p550=6) or were not available to work (p547=1 and p548=2). This applies to all individuals

who were not working (pre_r3=2), or unpaid family workers and others who worked less than 15 hours despite being categorized as working the previous week (pre_r3 = 1).

The remaining variables apply to the universe of employed individuals:

- Private wage employee: Individuals who are white-collar (p507=3) or blue-collar workers (p507=4) and work for public enterprises, cooperative, temporal employment agencies, private companies, or others (p510=3 to 7).
- Public wage employee: Individuals who are white-collar (p507=3) or blue-collar workers (p507=4) and work by Armed Forces and the National Police, or the Public Administration (p510=1 to 2).
- Private non-wage employee: Individuals who are employers (p507=1), self-employees (p507=2), unpaid family worker (p507=5 or 7), domestic workers (p507=6), or others. These categories are also separated by dummy variables indicating each specific employment type.
- Want and can work more: Individuals who wants to work more (p521=1) and are available to do so (p521a=1)
- Contract existence: For wage employees, the variable indicates having a contract if they report any type of contract (p511a is not 7). For self-employed individuals or employers, it indicates formality when the business is registered as a legal entity (p510a=1) or when the accounts of the business or company are kept using accounting books (p510a=2 and p510b=1). It is considered without a contract when the wage employee reports having no contract (p511a =7), or when there is neither a legal registration nor accounting books (p510a=2 and p510b=2).
- Enrollment in a pension system: The individual is considered enrolled if covered by any type of pension system (answered yes to at least one of the questions p558a1 to p558a4).
- Enrollment in a health insurance: The individual is considered enrolled if in any type of health insurance (answered yes to at least one of the questions p4191 to p4198).
- Working more than 48 hours: The individual works more than 48 hours per week in total
- Earning an income above legal minimum wage: The total income from the primary job (sum of monetary and in-kind payments) is greater than or equal to the legal minimum wage of the corresponding year.

- Earning an income above poverty threshold: The total income from the primary and secondary jobs (sum of monetary and in-kind payments) is at least equal to the average poverty threshold. INEI calculates the household poverty threshold (*linea*) differentiated by natural region for each year. I estimate the individual poverty threshold by multiplying *linea* by the number of household members and dividing by the number of individuals in the ENAHO labor module, using the person weights from that module.
- Underemployment by hours: Individuals who work less than 35 hours in their main and secondary jobs (i513t and i518) and want and are able to work more hours.
- Underemployment by income: Individuals who earn an income (the sum of income from primary and secondary jobs, including both types of payments) below the poverty threshold and work more than 35 hours, or those who work fewer than 25 hours but do not want to or cannot work more hours.
- Informal worker status: Employed individuals classified as informal workers according to the methodology used for ENAHO (INEI, 2019) to measure the informal sector and informal employment using ENAHO data.
- Decent work: Following Gamero's (OIT, 2019) indicator of decent work, I construct a five-level indicator based on the variables of contract existence, income above the minimum wage, working hours, enrollment in health insurance, and enrollment in a pension system. The first two are defined as *basic* worker rights, and the last three as *complementary* rights.
    - Level 1: All five worker rights apply.
    - Level 2: All basic rights apply (contract and income above minimum wage), but at least one complementary right does not
    - Level 3: Only one of the basic rights applies.
    - Level 4: None of the basic rights apply, but at least one complementary right does.
    - Level 5: None of the rights apply.
- Economic activity of the business where you are a private wage or non-wage employee. I use p506r4 that corresponds to the national adaptation of the International Standard Classification of All Economic Activities (ISIC), Revision 4, developed by INEI.
    - Agriculture: Businesses with p506r4 codes between 100 and 399
    - Manufacture: Businesses with p506r4 codes 1010, 1020, 1030, 1040, 1050, 1061, or 1062.

- Mining: Businesses with p506r4 codes between 500 and 999
- Non-agriculture important sectors: There are construction (4100 to 4399), sales (4500 to 4799), and personnel services (5500 to 5699 or 9500 to 9699).

- Income from primary wage job: The sum of monetary (d524a1) and in-kind (d529t) income from the primary job, when the individual is a wage employee. Both components are deflated to 2009 prices.
- Income from primary non-wage job: The sum of monetary (d530a) and in-kind (d536) income from the primary job, when the individual is self-employed or in non-wage employment. Both components are deflated to 2009 prices.
- Income from primary job: Since wage and non-wage employment are mutually exclusive categories, this variable equals the income from the primary job whether it comes from wage or non-wage employment.
- Monetary income from primary job: It takes into account only the components that are monetary payments (d524a1 and d530a), all of which are deflated to 2009 prices.

Appendix 3. Parallel trend tests (individual and joint) for all labor outcomes

	Individual tests						Joint test
Variable	J=-7	J=-6	J=-5	J=-4	J=-3	J=-2	All
Employed	0.088*	0.035*	0.019	0.005	-0.009	-0.002	***
Unemployed	-0.003	-0.006	-0.010**	-0.006**	-0.003	-0.003*	**
First-time unemployed	0.002	-0.002	-0.002	0.001	-0.000	0.001	
Unemployed with prior work experience	-0.005	-0.005	-0.008**	-0.007***	-0.003	-0.004***	***
Share of inactive	-0.084*	-0.029	-0.009	0.001	0.012	0.006	***
Public wage employee	-0.068***	0.010	-0.010	0.002	0.003	-0.001	***
Private wage employee	0.007	0.039	0.023	0.023	-0.003	-0.002	**
Private non-wage employee	0.061**	-0.049*	-0.013	-0.025	0.000	0.003	**
Employer	0.021	-0.020	-0.031***	-0.003	-0.007	-0.000	
Self-employee	-0.034	-0.028	0.003	-0.008	0.009	-0.002	
Unpaid family worker	0.073	-0.003	0.019	-0.018	-0.002	0.009	***

	Individual tests						Joint test
Variable	J=-7	J=-6	J=-5	J=-4	J=-3	J=-2	All
Domestic worker	0.001	0.002	-0.005	0.003	0.000	-0.004	*
Earning income above minimum wage	0.001	0.046	-0.006	0.004	0.013	0.015*	**
Earning income above poverty threshold	0.012	0.056**	0.007	0.000	0.014	0.018**	***
With contract	-0.025	0.023	0.018	0.018	0.007	-0.003	**
Workers working more than 48 hours per week	-0.029	0.027	0.003	0.022	0.003	0.006	***
Enrolled in a pension system	-0.179***	-0.053	-0.066**	-0.035	-0.006	-0.004	***
Enrolled in a health insurance	0.020	0.019	0.030*	0.016	0.017**	0.003	
Want and can work more	-0.019	-0.009	-0.035	0.013	0.013	0.029***	**
Informal workers	-0.019	0.025	0.009	0.008	0.010*	0.007	***
Decent workers (1st and 2nd levels)	0.002	0.021**	0.018**	0.013**	0.008**	0.002	
Decent workers (5th level)	0.062*	-0.032*	0.036	0.006	0.009	-0.005	***
Underemployed by hours	-0.053*	-0.012	-0.032***	-0.004	0.003	0.004	
Underemployed by income	0.049	-0.044	0.024	0.003	-0.016	-0.022***	***
Workers in agriculture	0.055	-0.015	0.052	0.005	0.001	-0.006	
Workers in manufacture	0.007	0.011	0.005	-0.002	0.006	0.003	
Workers in mining	-0.007	-0.006	-0.008	0.002	0.005	0.007***	
Workers in construction	0.008	0.010	0.004	0.002	0.000	0.004	*
Workers in sales	-0.051*	-0.030	-0.027	0.001	-0.007	-0.002	*
Workers in personnel services	-0.009	-0.024*	-0.037***	-0.025***	-0.009*	-0.002	**
Workers in other non-agriculture important sectors	-0.054	-0.043	-0.061*	-0.023	-0.016	0.000	
Workers in other sectors	-0.000	0.053**	0.011	0.018*	0.004	-0.004	*
Income from primary job	19.742	3.329	-34.750	-25.661	14.883	9.922	
Monetary income from primary job	27.700	22.536	-20.206	-9.765	20.206	10.493	
Income from primary wage job	20.035	80.138	-14.694	-20.505	-17.840	34.195*	**

	Individual tests						Joint test
Variable	J=-7	J=-6	J=-5	J=-4	J=-3	J=-2	All
Income from primary non-wage job	-33.007	-39.513	-27.391	-33.285	23.305	-16.556	
Income from primary job (log value)	0.264**	0.089	-0.093	-0.032	0.043	0.044*	***
Monetary income from primary job (log value)	0.341*	0.232	-0.100	0.064	0.067	0.063**	*
Income from primary wage job (log value)	0.409**	0.326***	-0.000	0.065	-0.014	0.071**	***
Income from primary non-wage job (log value)	0.185	-0.061	-0.106	-0.092	0.057	0.022	

Notes: The cells show the coefficients along with their significance levels: *** for 1%, ** for 5%, and * for 10%.