Manifestations, drivers, and frictions of mobile phone use in low- and middle-income settings: A mixed methods analysis of rural India and China

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Abbreviations

GSMA	Groupe Speciale Mobile Association
OLS	Ordinary Least Squares

Conflicts of Interest

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Abstract

Against the backdrop of alleged mobile phone ubiquity and the enthusiasm about the developmental value of mobile technology, this paper examines the manifestations, drivers, and frictions of mobile phone use in two low- and middle-income settings where mobile technology has diffused rapidly. Qualitative data from 231 participants and survey data from 800 adults in rural Rajasthan and Gansu provide consistent and strong support for the claim that the notion of "ubiquity" can mislead development practice because it obscures persistent non-use, under-utilisation, and heterogeneous engagement with mobile technology despite its apparently wide accessibility in the rural field sites. The paper suggests avenues for further work on the indicators of technology adoption, and it cautions that phone-based development interventions (and their benefits) may diffuse unevenly if the assumption of ubiquitous technology use is violated.

Main Text

1 Introduction

According to the International Telecommunication Union (ITU), the number of mobile phone subscriptions worldwide has increased 10-fold to more than seven billion during the last 15 years (ITU, 2015). This rapid spread of mobile phones worldwide excites: Variations of the phrase "mobile phones have become ubiquitous" generate up to 133,000 search results on Google (Google Inc., 2016);[i] over two million smartphone apps had been developed by 2013 (research2guidance, 2013); and mobile phones are increasingly being used as a vehicle for development interventions and public/private service delivery in high-, middle-, and low-income countries. For example, as of 25 March 2016, the industry group Groupe Speciale Mobile Association (GSMA) recorded worldwide 131 ongoing and planned mobile phone projects in the area of agriculture, 372 in finance, and 1141 in health (GSMA, 2016a, b, c). In light of the assumed ubiquity of mobile phones and the enthusiasm about developmental value of mobile technology, this paper challenges the binary logic of adoption that is implicit in the "ubiquity" narrative (Feder, Just, & Zilberman, 1985; Foster & Rosenzweig, 2010; Rogers, 2003; Torrance, 2012), and which has been criticised repeatedly for being "too narrow", "too static", and for "[hiding] the richness of the landscape" (Donner & Tellez, 2008, p. 327; Fernández-Ardèvol, 2014, p. 123; Karnowski, von Pape, & Wirth, 2011).

My research question is, *What are the manifestations, drivers, and frictions of mobile phone use in low- and middle-income settings where mobile technology has diffused rapidly?* In response to the limitations of binary adoption measures, I deploy and analyse a multidimensional and decomposable index of mobile phone utilisation that captures functional engagement as well as different access routes to mobile phones. The regional focus of this study is rural Rajasthan (India) and rural Gansu (China), which are two low- and middle-income contexts that resonate with the "ubiquity" discourse and that have featured repeatedly in narratives about the development potential of mobile-phone-based solutions (esp. in the context

of health-related applications for rural developing areas; Ling & Xiao, 2012; Qiang, Yamamichi, Hausman, Miller, & Altman, 2012; Walsham, 2010).

My analysis draws on the wider anthropological, sociological, and economic literature of mobile phone and technology adoption to examine the notion of mobile phone "adoption" that underlies the ubiquity narrative. The analysis also draws parallels to another body of work in development studies, namely the proximate illiteracy literature (Basu & Foster, 1998; Basu, Narayan, & Ravallion, 2001; Iversen & Palmer-Jones, 2008; Maddox & Esposito, 2013; Mishra, 2005; Subramanian, 2004, 2008),[ii] for three reasons. First, "technical literacy" required to operate a phone relates to the broader theme of literacy. Second, mobile phone use can resemble situations of proximate illiteracy when third parties help non-users to operate or derive benefits from mobile phones (Maddox & Esposito, 2013). Third, the concept of phone utilisation relates to the concept of "effective literacy" (Basu & Foster, 1998, p. 1746): because literacy (read: phone use) is socially embedded, nominal rates of illiteracy (read: adoption) mask externalities of sharing and transacting literacy (read: phone use) within and across households, and they disguise the ensuing distribution and stratification of its social consequences.

2 The Anthropological, Sociological, and Economic Mobile Phone Adoption Literature

The recent qualitative literature on the consequences of mobile phone diffusion processes has involved for instance concerns about the relationship between phone diffusion and economic activity (Donner, 2009), political participation (Gagliardone, 2016), health (Anstey Watkins, Goudge, Gómez-Olivé, & Griffiths, 2018), and culture and identity (Doron, 2012), but a central theme has also been migration and mobility (Archambault, 2012; Porter et al., 2012; Thornham & Gómez Cruz, 2017). For example, Horst (2006, pp. 147-148) described how mobility patterns of families could shape the use of mobile phones to maintain and mediate "transnational" family relationships of Jamaican phone users, while cases from Ureta (2008) in

Chile and Thornham and Gómez Cruz (2017) in the UK illustrated how mobile phones might expand people's physical mobility only to a very narrow extent or even create new forms of immobility. This body of research has highlighted the contextually varied ways in which mobile phones enable, sustain, restrict, and reconfigure mobility patterns—thereby representing one facet of the social implications of technology diffusion, but also underlining the wide and partly unexpected ways in which mobile phones can be utilised and hinting at the context-specific social determinants of these utilisation patterns.

The qualitative literature is indeed rich in examples of heterogeneous and perhaps surprising forms of mobile phone use. For instance, Dodson, Sterling, and Bennett (2013, p. 82) studied female phone users in Morocco and found that "taboos on mixed-gender communication" in face-to-face interaction are reproduced in mobile communication. Qualitative research has also documented the socially embedded modes in which people access mobile technology. Aside from sharing and borrowing mobile phones, studies from high-, middle-, and low-income contexts thereby report the widespread presence of third parties who extend mobile phone access by operating phones of the behalf of the beneficiary (Fernández-Ardèvol, 2012; Reisdorf, Axelsson, & Söderholm, 2012; Tenhunen, 2008)—similar to the arguments of externalities in the proximate illiteracy literature, according to which the benefits of the resource (be it literacy or mobile phones) can be shared by or procured from others (Basu et al., 2001; Iversen & Palmer-Jones, 2008; Maddox & Esposito, 2013).

The qualitative literature has also suggested determinants of these patterns, for instance user characteristics (Chipchase, 2008; Dey, Newman, & Prendergast, 2011; Dodson et al., 2013), the technical specifications of the phone (Donner, Rangaswamy, Steenson, & Wei, 2008; Souter et al., 2005; Tenhunen, 2008; Wei & Zhang, 2008), or the social context and mobility patterns of individuals (D'Souza, 2010; Fernández-Ardèvol, 2014; Jeffrey & Doron, 2013; Oreglia & Kaye, 2012) (see Section 3 for further references). For example, user characteristics

like illiteracy or old age can limit the engagement with mobile phones, or even render them unusable altogether. Yet, technical features like pictographs and other visual or audio aides can also mitigate some of these constraints (Kurniawan, 2008; Ziefle & Bay, 2005).

Overall, the qualitative mobile phone literature suggests that we should expect locally emerging usage and access patterns, and it suggests a wide range of factors that can contribute to such forms of mobile phone use. The quantitative measurement of mobile phone adoption in the economic and sociological literature does not capture this heterogeneity. These limitations become apparent by reviewing the main indicators in mobile phone adoption measurement, which are summarised in Table 1 and which are typically unable to capture the breadth of adoption behaviours and instead rely on binary or one-dimensional measurement.

139 Table 1. Types and Examples of Mobile Phone Adoption Indicators

Types of Indicators	Example Indicators	Example Sources
Ownership Indicators	Personal ownership	Kavetsos and Koutroumpis (2011); Lee and Bellemare (2013, p. 628); Rice and Pearce (2015)
	Household ownership	Graham and Nikolova (2013); Lee and Bellemare (2013); Martin and Abbott (2011)
Revealed Use	"Owners" and "non-owners who share"	Kwon and Chidambaram (2000); Palackal et al. (2011); Wesolowski, Eagle, Noor, Snow, and Buckee (2012)
	Any calls made in last three months	de Silva, Ratnadiwakara, and Zainudeen (2011)
	Phone use (as one communication channel)	Palackal et al. (2011); Zanello, Srinivasan, and Shankar (2014)
	Usage scales (e.g. call minutes per day)	Davis, Bagozzi, and Warshaw (1989); Kaba, N'Da, Meso, and Mbarika (2009); Kwon and Chidambaram (2000)
User-Generated Data	Phone logs	Donner (2007)
	Network operator records	Miritello et al. (2013); Saramäki et al. (2014); Wesolowski, Eagle, Noor, Snow, and Buckee (2013)
Aggregate Penetration Data	Teledensity	Bailard (2009); Chavula (2012); Stump, Wen Gong, and Zhan Li (2008)
	Start of mobile network roll-out	Aker and Fafchamps (2014); Bailard (2009); Jensen (2007)
Composite Indices	National-level adoption index	Bruno, Esposito, Genovese, and Gwebu (2010); Farhadi, Ismail, and Fooladi (2012); Katz, Koutroumpis, and Callorda (2014)
	Mobile phone appropriation index	Lee, von Pape, and Karnowski (2012); Wirth, Von Pape, and Karnowski (2008)
	Mobile phone personalisation index	Tossell, Kortum, Shepard, Rahmati, and Zhong (2012)

140 Source: Author.
141

142 The most common indicators of mobile phone adoption are based on ownership or one-
143 dimensional conceptions of revealed use (Duncombe, 2011; Hübler & Hartje, 2016; Karnowski
144 et al., 2011; Martin & Abbott, 2011; May & Diga, 2015; Zanello, 2012), which are susceptible
145 to misrepresenting intricate and partly unpredictable adoption patterns. User-generated data
146 maintained by mobile network providers can enable a more extensive view on technologically
147 mediated social behaviour, but they, too, suffer from a radical reduction of usage dimensions
148 and potential discrepancies between the users, owners, and beneficiaries of mobile phones.

Aggregated usage and coverage data may be better suited to assess exhaustively the implications of phone diffusion on specific social and economic facets in a given region, while being unable to uncover heterogeneous forms of use and their contributions to development on the individual level. Only a small yet growing number of composite indices captures the multidimensionality of technology adoption. For example, Lee et al. (2012) use 85 indicators to construct their usage index (e.g. the frequency of changing ringtones), which exposes the challenge of simplification and dimension reduction in multidimensional index construction. Depending on the purpose of the investigation, it appears reasonable to develop such indicators locally to strike a balance between reductionism and unworkable complexity.

This outline of mobile phone adoption measurement highlights the difficulties in assessing quantitatively the complex and context-specific patterns of mobile phone adoption. Considering these challenges, it is conceivable that the empirical reduction of the concept of adoption into binary and one-dimensional indicators perpetuates the notion of "ubiquity" as it obscures intricate patterns of usage and exclusion.

3 Materials and Methods

This paper examines the nature and determinants of mobile phone use in rural in Gansu (China) and Rajasthan (India) as part of a broader mixed methods research project on the relationship between mobile phone use and rural healthcare access (using an exploratory mixed methods research design that links qualitative and quantitative methods sequentially and that does not give precedence of one method over the other).[iii] Rural Rajasthan and Gansu were chosen as comparatively poor low- and middle-income contexts with increasing mobile phone penetration (74 subscriptions per 100 persons when the study was designed), which make them interesting candidates for a study of mobile phone use within development studies research (China Marketing Research, 2014; Datanet India, 2014; IMF, 2015; ISI Emerging Markets, 2012, 2013).

The mixed methods research design comprised two stages. The first stage developed a grounded framework of mobile phone use through qualitative data collected between September and December 2013 (Table 2 summarises the qualitative sample). Community-level interviews and focus group discussions with 89 adult villagers per site were the centrepiece of this fieldwork phase (sampled purposively to ensure maximum variance). Supplementary interviews with 53 experts helped to contextualise the community interviews, who were sampled purposively according their expertise of national-, state-, and local-level conditions of the telecommunication and health contexts (Arksey & Knight, 1999; Morgan, 2008).

Table 2. Summary of Qualitative Sample

	Number of Sessions		Number of Respondents	
	Rajasthan	Gansu	Rajasthan	Gansu
		Community Interviews		
Individual Interviews	22	24	22	24
Dual Interviews	8	13	16	26
Focus Groups	10	11	51	39
Total	**40**	**48**	**89**	**89**
		Expert Interviews		
Local Shop Owners	5	5	5	5
Local Health Staff	13	7	14	7
District Health Experts	2	1	2	1
Mobile Network Operators	3	1	7	1
mHealth Service Providers	4	2	4	3
Telecom Regulators	2	0	4	0
Total	**29**	**16**	**36**	**17**

Source: Author.

I analysed the community interviews using categorical and holistic thematic analysis (Kohler Riessman, 2006; Lieblich, Tuval-Mashiach, & Zilber, 1998; Mishler, 1986). Besides the specific interview content, this method is sensitive to the linkages between villagers' reported behaviour and their social and economic position in their local communities, and it

appreciates the iterative evolution of the interview process as well as the dynamic nature of focus group discussions (Barbour, 2007; Lapadat, 2010; Lloyd-Evans, 2006; Stewart, Shamdasani, & Rook, 2007). I used categorical analysis for the supplementary expert interviews to extract the specific contextual elements required to situate villagers' interview responses. The qualitative analysis was carried out using Nvivo 10 (QSR International, 2014).

A subsequent quantitative stage involved primary survey data collection from 800 villagers in the same field sites from August to October 2014. The survey involved a three-stage stratified cluster random sampling design (described in more detail in Haenssgen, 2015b) to select 16 villages across eight sub-districts in each field site. Within each village, I selected randomly 25 households using interval sampling, from which one member was selected randomly (summary data of the survey sample is presented in Appendix Table 1, and the variables are explained in Appendix Table 2). The survey instrument was a 60-minute questionnaire that was developed based on the preceding qualitative research and which placed particular emphasis on the use of different phone functions personally, in shared arrangements, through borrowed phones, or by third parties (see appendixes in Haenssgen, 2015a).

My exploratory quantitative analysis integrated into the qualitative analysis and used descriptive statistics and regression analysis. The descriptive analysis examined the manifestations and patterns of mobile phone use, using district-level representative statistics through sample weights based on census data (Government of India, 2011; Heeringa, West, & Berglund, 2010; NBS, 2013). Regression analysis estimated the factors accounting for the variation in mobile phone utilisation in general and among mobile phone owners in particular. Individual-level mobile phone utilisation was estimated in the following linear regression model:

$$\boldsymbol{Utilisation}_i = \alpha + \beta_p \boldsymbol{Personal}_i + \beta_t \boldsymbol{Technical}_i + \beta_s \boldsymbol{Social}_i + \beta_c \boldsymbol{Contextual}_i + \varepsilon_i \quad (1)$$

In this model, ***Utilisation***$_i$ is the respondent's mobile phone use, measured through a multidimensional and decomposable utilisation index that goes beyond conventional adoption measures and represents different manifestations of mobile phone use (Haenssgen, 2015a). As described in Appendix Table 2, the aggregate index ranges from 0 to 1 and measures the extent to which six different mobile phone functions were used directly or indirectly by the respondent in the past year (0 corresponding to less than monthly use of any function or "minimal utilisation"; 1 corresponding to daily use of all six functions or "full utilisation"). Sub-indexes across different access modes and mobile phone functions help to capture individual facets of phone use, for instance the degree to which third parties operate one's phone, or the extent of mobile Internet use. The interpretation of this utilisation index is therefore distinct from nominal ownership because it captures "effective use" of mobile phones by measuring the extent of socially embedded proxy use, sharing, borrowing, and transactional mobile phone use with a reference period of one year. The construction of the index emphasises functional use (rather than symbolic use), and it is implicitly weighted towards the highly variable basic mobile phone uses in the two field sites due to its focus on the six mobile phone functions incoming/outgoing calls, incoming/outgoing text messages, mobile data use, and in-built tool use. This means that a mobile phone utilisation index for instance in urban high-income country contexts would be likely to involve a broader spectrum of advanced functions in order to capture local variations of mobile phone use effectively (consider e.g. the various dimensions of mobile phone appropriation in Lee et al., 2012).

The control variables in this model represent the determinants of utilisation, which were derived from the qualitative analysis together with the aforementioned mobile phone literature. The regression models include thus vectors of ***Personal***$_i$ factors (Chipchase, 2008; Dey et al., 2011; Dodson et al., 2013); ***Technical***$_i$ mobile-phone-specific factors (Donner et al., 2008;

Souter et al., 2005; Tenhunen, 2008; Wei & Zhang, 2008); ***Contextual***$_i$ factors relating to complementarities and the technological environment (captured through village dummy variables) (Ndiaye & Zouinar, 2014; Wicander, 2010); and the ***Social***$_i$ context of the individual (D'Souza, 2010; Fernández-Ardèvol, 2014; Jeffrey & Doron, 2013; Oreglia & Kaye, 2012). The number of variables entering the quantitative analysis was reduced through multicollinearity analysis (see Supplemental File 1 for the correlation matrix of included variables) and the full list of control variables is defined and described in Appendix Table 2.

The regression models were estimated for the aggregate utilisation index and individually for each sub-index—firstly for the general population irrespective of mobile phone ownership (considering common indirect routes of access), secondly for mobile phone owners in particular to explore variation in their phone utilisation. The analysis was carried out separately for Rajasthan and Gansu to take account of the contextual variation that emerged from the qualitative analysis. Breusch-Pagan/Cook-Weisberg tests (Breusch & Pagan, 1979; Cook & Weisberg, 1983) and White tests (White, 1980) for heteroscedasticity were significant at the 10% level for two out of the 36 estimated models. To adhere to convention nevertheless, the regression results are reported with heteroscedasticity-robust standard errors.

In Supplemental File 2, I included robustness checks involving nested models considering the heterogeneity of significance levels of the independent variables across the different index dimensions. The nested models included only variables for sex, education, age, and wealth plus mobile phone ownership and dummy variables for village and ethnic groups. I further included in Supplemental File 3 for illustration a robustness check of the reverse causality argument that mobile phone use enabled more effective education (see the discussion in Section 5), estimating the nested models through two-stage least squares estimates of phone utilisation. These models instrumented education through literacy (i.e. ability to read in the mother tongue as reported by the respondent), assuming that illiteracy represented those people

who were unable to attain formal education whereas mobile phone use would have affected the education of people enrolled in schools. Although this variable was an imperfect instrument for educational attainment because it, too, may be affected indirectly by mobile phone diffusion, Wooldridge score tests of endogeneity did indicate that educational attainment was endogenous for some of the estimated models (Wooldridge, 2010). Despite the limitations of the two-stage least squares approach, the robustness tests involving nested and two-stage least squares models confirmed the general trend of the full model in which education emerged as an important and significant correlate of phone utilisation across the various index dimensions, while other social determinants of phone utilisation like sex and wealth varied across the social contexts of the two field sites.

Additional robustness checks reported in Supplemental File 4 involved estimations with sample weights, dropping the least reliable survey responses, and random-intercept multilevel models that appreciate village and sub-district clustering (which proved no more efficient than single-level ordinary least squares [OLS] estimation). While the significance of some covariates across the various models was sensitive to the robustness checks, the overall implications of the quantitative analysis continued to hold, namely that the variation of phone utilisation is not determined solely by phone ownership but also individual, social, and technical factors. The quantitative analysis was carried out using Stata 13 (StataCorp, 2013).

4 Results

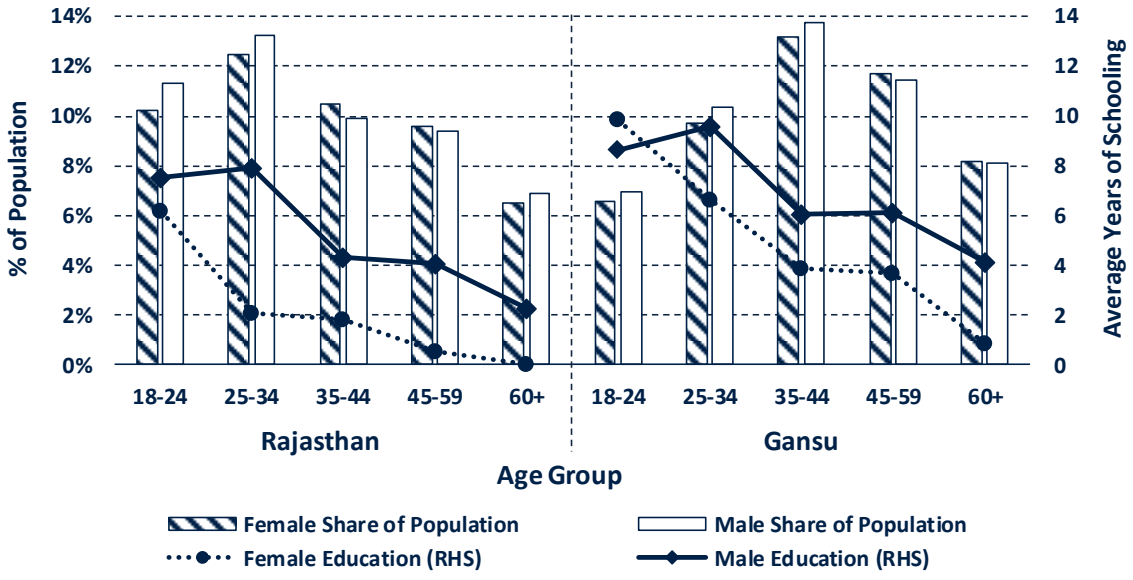
Following a brief description of the socio-economic context of the field sites (Section 4.1), the results of the qualitative and quantitative analysis will be presented side-by-side and structured by access patterns of mobile phones (Section 4.2), the manifestations of mobile phone use across the population (Section 4.3), and the drivers and frictions that determine the variation of mobile phone use across the field sites (Section 4.4). In summary, nominal access to mobile phones was more extensive in both field sites than ownership rates suggest, but

mobile phone functions remained underutilised and mobile phone exclusion persisted. Some sources of variation of mobile phone use were site specific (e.g. mobility patterns and household structure), and others emerged commonly across rural Rajasthan and Gansu (e.g. frictions in technological learning and literacy). The findings will highlight the social embeddedness of mobile phones, which resonates with patterns in the proximate illiteracy literature, which undermines the notion of mobile phone "ubiquity" in Rajasthan and Gansu, and which leads me to hypothesise that mobile-phone-based development interventions can reproduce existing social divisions.

4.1 Summary of Socio-Economic Field Site Context

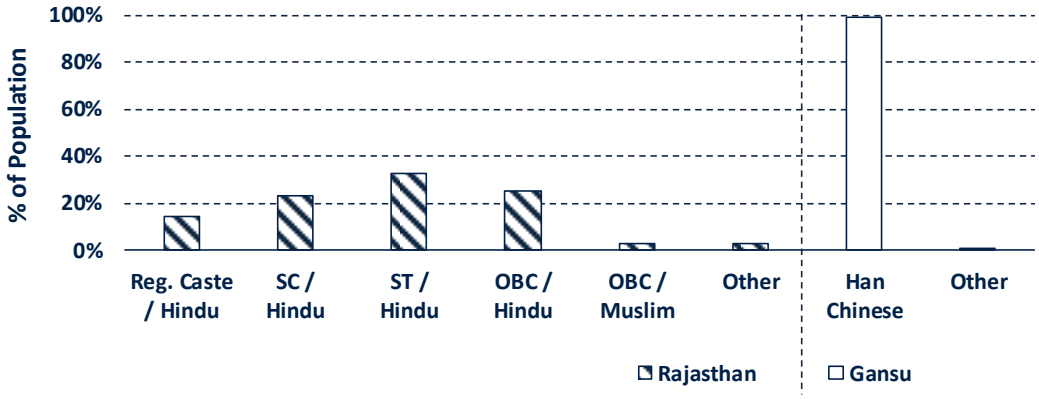
Although both field sites were relatively poor within their countries and had similar degrees of mobile phone penetration, the household survey data highlighted differences in terms of age structure, education, social mobility, ethnic fragmentation, and household wealth. As shown in Figure 1, Gansu had a slightly older population and higher education levels on average. However, in both sites, the average number of completed years of schooling fell with age, and women tended to have lower formal educational attainment than men. Moreover, the population in the Gansu site was ethnically more uniform, with only 1% not belonging to the dominant Han group (Figure 2). The spectrum of social groups in Rajasthan in terms of caste-religion composition was more fragmented and more than 80% belonged to government-recognised disadvantaged groups.

Figure 1. Demographic Composition and Education of Survey Samples (Weighted)



Source: Author.
Notes: *n*=798. Statistics are population weighted across the field site districts using census data. Proportion as share of total adult population in field site. "RHS" is right-hand side.

Figure 2. Social and Ethnic Composition of Field Sites

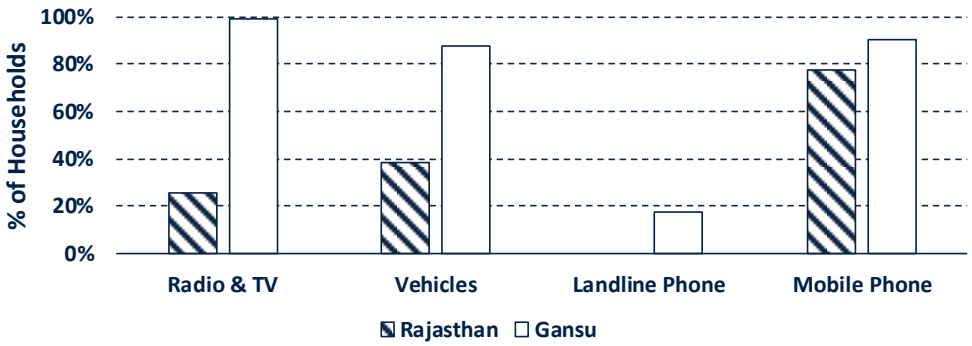


Source: Author.
Notes: *n*=798. "Reg. Caste" is regular caste, "SC" is scheduled caste, "ST" is scheduled tribe, "OBC" is "other backward class". Underlying statistics are population-weighted using census data. Proportion as share of rural population.

Major differences emerged also in the social composition of households. Households in the Rajasthan sample were on average larger by two members (5.4 vs. 3.5). This meant that a villager in Rajasthan was more likely to have tighter family social networks surrounding them compared to Gansu, where the qualitative fieldwork indicated higher individualism among the

smaller and older rural households. The smaller household size in Gansu was also symptomatic for fundamentally different mobility patterns across the two sites. More than 80% of households in Rajasthan did not have a core family member living outside their village, whereas the same was the case for less than 20% of households in Gansu. Households in Gansu were also wealthier: Mass media, transportation, and communication assets were in wider ownership (Figure 3), although the gap in household mobile phone ownership across the field sites was comparatively small (78% vs. 90%).

Figure 3. Comparison of Selected Household Assets



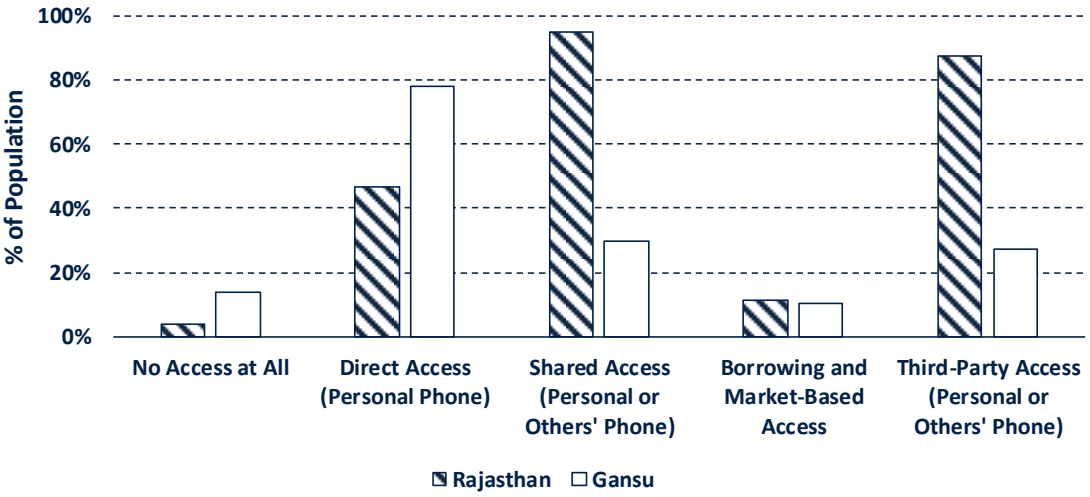
Source: Author.
Notes: n=798. Underlying statistics are population-weighted using census data. Proportion as share of rural households.

4.2 Mobile Phone Access Patterns

At first glance, mobile phones had diffused widely in both sites, with 78% of Rajasthan households (47% of adults) and 90% of Gansu households (78% of adults) owning at least one mobile. Yet, access patterns were more complex than what ownership figures suggest. For instance, 56% of the Rajasthan site population used very basic phones and less than a quarter owned or shared an Internet-enabled feature phone or smartphone, whereas 56% of the adults in the Gansu site owned or shared an Internet-enabled phone. More broadly, Figure 4 summarises the access routes to mobile phones and highlights that (a) various forms of indirect access meant that exclusion from mobile phones ("no access") was uncommon (but still

present) in both sites; (b) personal mobile phone use was more common in Gansu; (c) sharing and third-party use were more common in Rajasthan; and (d) people did not often borrow or rent mobile phones in either site.

Figure 4. Mobile Phone Access Patterns Across Field Sites



Source: Author, adapted from Haenssgen (2015a, p. 4).
Notes: n=798. Underlying statistics are population-weighted using census data. Proportion as share of total adult population in field site.

The qualitative data adds further depth to these observations. For instance, sharing was commonly understood as mutual ownership or joint use between family members and close friends, whereas "borrowing" involved a request from the borrower and the permission of the phone owner. This conceptualisation affected access patterns. For example, an affluent married couple in a Chinese village explained that, among young people, phone borrowing did "*not* [happen] *very much, maybe sometimes only to call relatives*" (Gansu, man, 23, phone owner) and "*not* […] *for games or Internet*" (Gansu, woman, 24, phone owner). However, young people occasionally shared their phones because, "*sometimes we sit together and have nothing to do, and they can look what kind of games you have on the phones, and take the phones to play games*" (Gansu, woman, 24, phone owner).

The common incidence of third-party use—where one person handled some or all functions of a phone on behalf of the beneficiary—reflected convenience (e.g. the beneficiary being engaged elsewhere and unable to pick up the phone) but also inability (e.g. [technical] illiteracy). For example, an illiterate female mobile phone owner in Gansu would ask her son to communicate via texts with her daughter (living elsewhere) to enquire "*what she has been recently doing*" (Gansu, woman, 43, phone owner). The higher occurrence of third-party use in Rajasthan appeared to reflect an environment where the villagers' social networks were denser (owing to larger households and lower degrees of mobility), and where literacy rates were lower (47% vs. 71%). In Gansu, the more individualised use of mobile phones meant that (technical) illiteracy would become a greater obstacle to mobile phone access when younger family out-migrate temporarily or permanently.

4.3 Manifestations of Mobile Phone Use

I have established thus far that mobile phones diffused widely in rural Rajasthan and Gansu, and that access to mobile technology was yet more extensive even if a small share of the population remained excluded. Yet, full utilisation does not follow automatically from mobile phone diffusion, and examples of the varied manifestations of mobile phone use included,

> "*From the contact list, I can recognise the number because we put the picture in front of the contact number, so I can know which number it is. For example, in front of my husband's number, I put some statues so I can know that it is his number*". (Rajasthan, men and women, 34 to 73 [group response, illiterate phone owner], mixed phone ownership)

"*I call directly or do QQ chat. Now I rarely send text messages, only a few messages per month*". (Gansu, man, 22 smartphone owner)

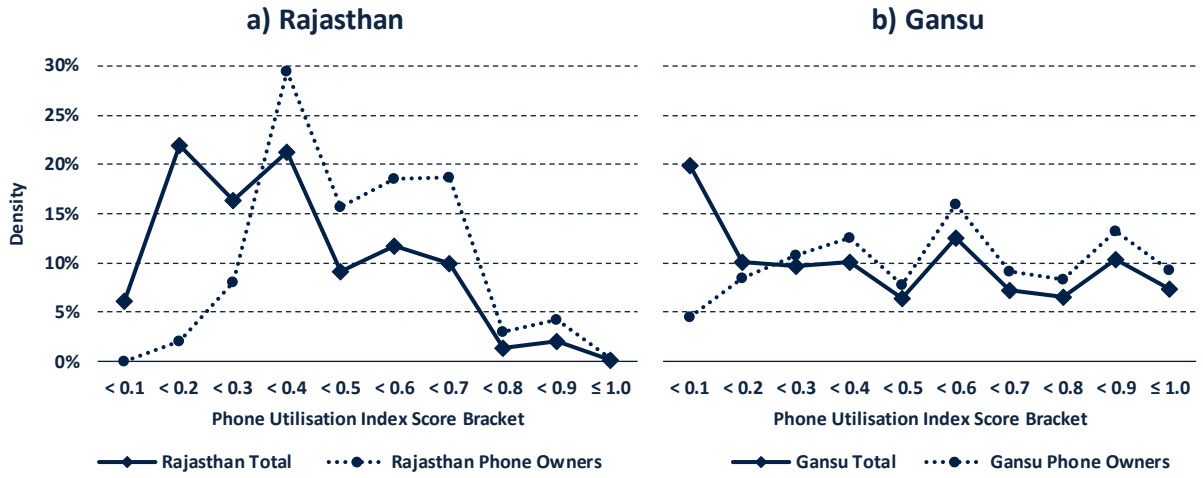
"*Whenever we go on a trip with family and friends, we take pictures and share them on Facebook because we all have a Facebook account*". (Rajasthan, men, 18 to 22 [group response], phone owners)

"*I applied for Internet services to read news and stopped it* [i.e. unsubscribed] *again after one week*". (Gansu, man, 36, smartphone owner)

These examples were not mere anecdotes, but they reflected the heterogeneity of mobile phone utilisation in my field sites. Mobile phone utilisation as a quantitative measure on the population level is depicted in Figure 5, both for the general population and specifically for people who own mobile phones. On a scale from 0 to 1, the highest degree of phone utilisation was 0.94 in Rajasthan and 1.0 in Gansu, but both panels in Figure 6 demonstrate a wide range of utilisation with estimated population means of 0.33 in Rajasthan (SD=0.20) and 0.43 in Gansu (SD=0.32). A counter-intuitive pattern was that a larger share of people in Gansu did not utilise mobile phones (20% vs. 5% in Rajasthan), even though personal phone ownership was more widespread. This can be explained with the prevailing access patterns, as 95% of the Rajasthan sample reported sharing arrangements and 88% reported third-party access to mobile phones, compared to 30% and 27% in Gansu. In the terminology of the proximate illiteracy literature, this would suggest that Rajasthan respondents realised more "externalities" in mobile phone use, whereas more individualistic social arrangements (e.g. two-person households) in Gansu resulted in a higher share of "isolated non-users". Yet, indirect access did not contribute to very high utilisation as only 3% of the Gansu population fell into the top-three brackets of

phone utilisation (0.7–1.0) but 24% in Gansu. Phone owners were less likely to fall into the lowest utilisation bracket of 0.0–0.1 and had higher average utilisation in both Rajasthan (mean=0.45, SD=0.17) and Gansu (mean=0.40, SD=0.26). However, the dotted lines in Figure 5 indicate that low and heterogeneous utilisation was common even in this group of "adopters".

Figure 5. Density Plots of Phone Utilisation Among General Population and Phone Owners



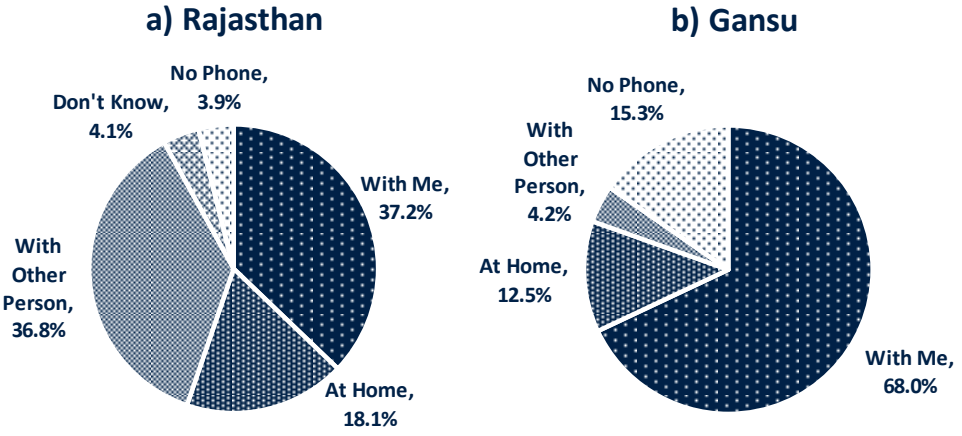
Source: Author.
Notes: General population: *n*=400 in Rajasthan, *n*=398 in Gansu. Phone owners: *n*=168 in Rajasthan, *n*=265 in Gansu. Underlying statistics are population-weighted using census data.

Further evidence of the heterogeneity of adoption patterns within and across contexts could be found in people's interaction with and management of their phones. For example, respondents in Gansu had used mobile phones on average three years longer than their Rajasthan counterparts (6.9 vs. 3.8 years) and spent 3.4 times the monthly amount on their mobile phones (adjusted for purchasing power parity; ₹88.27 or £0.88 in Rajasthan and ¥64.94 or £6.49 in Gansu; IMF, 2015). The higher rate of personal mobile phone ownership in Gansu also meant that most phones remained with the respondent throughout the day, whereas the typically shared phones in Rajasthan often remained at home or with another person when the respondents left their homes (see Figure 6, Panel a for Rajasthan and Panel b for Gansu). Even people who owned a phone would occasionally be heard saying, "*I am not very fond of having*

437 *a phone with me all the time*" (Rajasthan, man, 24, phone owner). A sole focus on adoption as
438 device ownership would obscure these varied patterns of mobile phone access and engagement.

439

440 Figure 6. Typical Location of Mobile Phone When Respondent is not at Home



441

442 Source: Author.
443 *Notes: n*=798. Underlying statistics are population-weighted using census data. Proportion as share of total adult population in
444 field site.

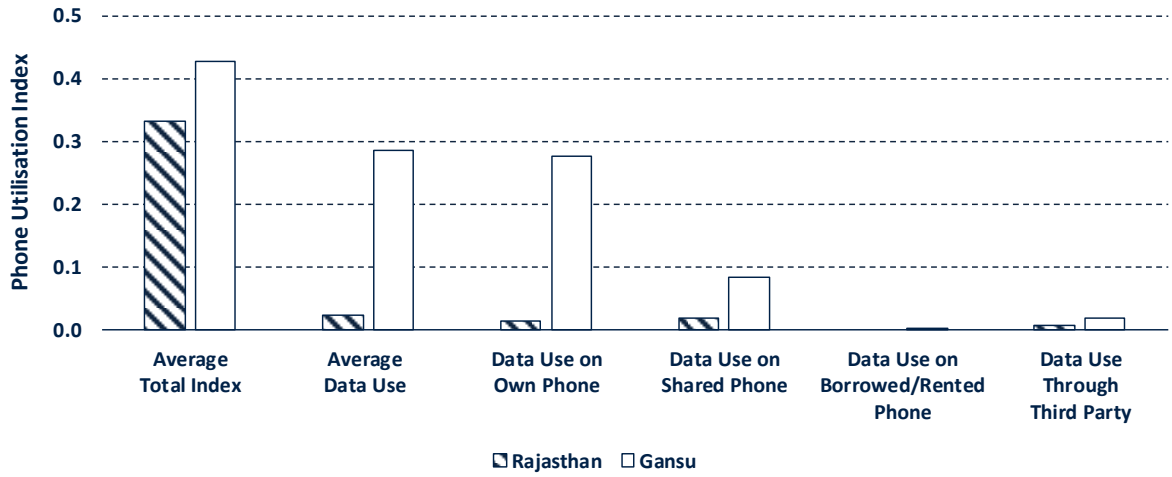
445 **4.4 Drivers and Frictions of Mobile Phone Use**

446 This final section explores the factors that drive the apparent heterogeneity in mobile
447 phone use, demonstrating that social factors and frictions in mobile phone access and use—
448 albeit specific to their context—played an important role in determining the wide range of
449 utilisation that I could observe in the field sites.

450 The example of mobile data use helps to illustrate the social correlates of mobile phone.
451 Although average phone utilisation was relatively similar in both field sites, mobile data
452 utilisation was substantially different in the two contexts (Figure 7). Mobile data use in the
453 Rajasthan site was almost non-existent, with an average index score of 0.02. It was considerably
454 higher in Gansu (with a score of 0.28), but hardly anyone in either site borrowed a phone or
455 asked someone to help them to browse the Web. In addition, Internet use in each place was
456 nearly or entirely absent for illiterate persons and for people in the age group 45-years-and-
457 above (Figure 8).

458

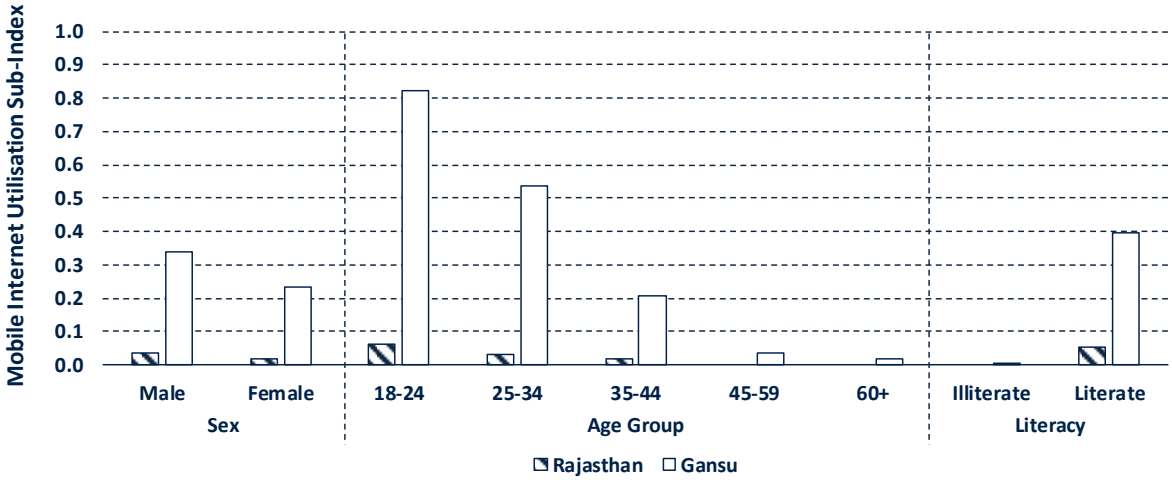
459 Figure 7. Mobile Phone and Mobile Data Utilisation Across Field Sites



460

461 Source: Author.
462 *Notes: n*=798. Underlying statistics are population-weighted using census data. Average scores based on total adult population
463 (including phone owners and non-owners). Utilisation index 1 indicates daily use of all functions and mobile data respectively;
464 index value 0 indicates that no function is used at least once a month.
465

466 Figure 8. Mobile Data Utilisation Across Socio-Demographic Groups in Field Sites



467

468 Source: Author.
469 *Notes: n*=798. Underlying statistics are population-weighted using census data. Average scores based on total adult population
470 in respective sub-group (including phone owners and non-owners). Utilisation index 1 indicates daily use of mobile data; index
471 value 0 indicates that mobile data is not used at least once a month.
472

473 The social embeddedness of mobile phone use was similarly visible in the regression

474 analysis of mobile phone utilisation and the various sub-indexes of access and functional use.

The main results of the single-level OLS regression analysis with heteroscedasticity-robust standard errors are summarised in Tables 3 and 4 for utilisation among general population (Rajasthan and Gansu respectively) and in Tables 5 and 6 for utilisation among phone owners. The overarching insights of these analyses are that (a) mobile phone ownership was unlikely to be the sole determinant of utilisation; (b) utilisation was linked to education and age but different forms of utilisation had different correlates; and (c) the drivers and frictions of utilisation varied across contexts.

Table 3. Regression Results: Determinants of Mobile Phone Utilisation, Rajasthan

		Access Sub-Index				Functional Sub-Index					
	Utilisation Index	Own Phone	Shared Phone	Borrowed Phone	3rd-Party Use	Incoming Calls	Outgoing Calls	Incoming SMS	Outgoing SMS	Mobile Internet	Tools
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Sex (Female)	-0.04*	-0.04***	-0.03	0.00	0.00	-0.03	-0.03	-0.07*	-0.02	0.01	-0.08*
Highest Grade	0.01***	0.01***	0.01***	0.00	0.00	0.00	0.01	0.02***	0.01**	0.01**	0.03***
Age Group	-0.02**	0.00	-0.02***	0.00	0.00	-0.03**	-0.03**	-0.01	0.00	0.00	-0.03*
Household Size	0.01*	0.00	0.01*	0.00	0.01*	0.01*	0.02**	0.00	0.00	0.00	0.01
Sex (HH Head)	0.02	0.02	0.03	0.00	0.01	-0.08	-0.07	0.05	0.02	0.02	0.15**
Highest Grade (HH Head)	0.01**	0.00	0.00	0.00	0.01*	0.01***	0.01***	0.00	0.00	0.00	0.01
Parents Living Elsewhere	-0.03	-0.02	0.01	-0.02	-0.01	0.04	-0.01	-0.06	-0.04	-0.02	-0.10
Spouse Living Elsewhere	0.04	0.00	0.02	-0.01	0.09*	0.06	0.06	-0.04	0.00	-0.02	0.21*
Siblings Living Elsewhere	0.03	0.02	-0.06	0.01	0.02	0.04	0.06	0.02	0.02	-0.01	0.03
Children Living Elsewhere	-0.02	-0.01	0.00	0.00	-0.02	-0.04	-0.03	0.08	-0.03	-0.01	-0.08
Wealth Index Quintile	0.00	-0.01	0.00	0.00	0.02***	0.02	0.02	-0.03*	-0.01	-0.01	0.01
Mobiles per HH Member	0.26***	0.15***	0.28***	0.00	0.03	0.37***	0.32***	0.44***	0.06	0.06	0.34***
HH Assets: Landline[a]											
HH Assets: Computer	0.04	0.10	0.03	0.01	0.05	-0.13	-0.11	0.27	0.04	0.05	0.12
Respondent Owns Phone	0.13***	0.38***	0.15***	0.00	0.02	0.25***	0.24***	0.08*	0.01	-0.02	0.23***
Constant	0.24**	0.06	0.23**	0.10***	0.01	0.50***	0.42**	0.41**	0.04	-0.01	0.04
R^2	0.68	0.87	0.71	0.25	0.29	0.59	0.56	0.42	0.15	0.19	0.56
Adjusted R^2	0.65	0.86	0.68	0.18	0.23	0.56	0.52	0.36	0.07	0.11	0.52

Source: Author.

Notes: n=400. Village and ethnicity dummies not reported. HH is household. Heteroscedasticity-robust standard errors.

[a]No landline phones in Rajasthan sample.

*p<0.05, **p<0.01, ***p<0.001.

Table 4. Regression Results: Determinants of Mobile Phone Utilisation, Gansu

		Access Sub-Index				Functional Sub-Index					
	Utilisation Index	Own Phone	Shared Phone	Borrowed Phone	3rd-Party Use	Incoming Calls	Outgoing Calls	Incoming SMS	Outgoing SMS	Mobile Internet	Tools
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Sex (Female)	-0.06*	-0.06**	0.01	-0.01*	-0.01	-0.09*	-0.13***	-0.06	0.00	0.02	-0.10*
Highest Grade	0.02***	0.02***	0.01*	0.00	0.00	0.01	0.02**	0.02***	0.01*	0.02***	0.02***
Age Group	-0.07***	-0.07***	-0.02	0.00	-0.01	0.00	-0.04	-0.07***	-0.09***	-0.12***	-0.10***
Household Size	0.01	0.00	0.02**	0.00	0.01	0.01	0.01	0.00	-0.01	0.01	0.01
Sex (HH Head)	0.04	0.05*	0.02	0.01	0.01	0.06	0.03	0.03	0.07	0.02	0.05
Highest Grade (HH Head)	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.01
Parents Living Elsewhere	-0.02	-0.04	0.00	0.00	0.00	0.03	0.08	-0.07	-0.05	-0.12***	0.01
Spouse Living Elsewhere	-0.03**	-0.03**	-0.03	0.00	-0.01	-0.02	-0.06*	-0.01	0.00	-0.02	-0.07**
Siblings Living Elsewhere	-0.03	-0.02	0.00	0.00	-0.02	-0.05	-0.05	-0.01	-0.01	-0.03	0.00
Children Living Elsewhere	0.02	0.02	0.03	0.00	0.02	0.04	0.02	0.02	0.03	-0.03	0.02
Wealth Index Quintile	0.01	0.01	0.02	0.00	-0.01	0.00	0.03	0.02	0.02	-0.02	0.03
Mobiles per HH Member	0.03	0.03	-0.03	0.00	0.01	0.02	0.02	0.02	0.04	0.10***	0.01
HH Assets: Landline	-0.05	-0.03	-0.04	0.00	0.00	-0.08*	-0.06	-0.08	-0.03	0.05	-0.07
HH Assets: Computer	0.04	0.04	0.03	0.00	0.01	0.09	0.01	0.03	0.02	0.11	-0.02
Respondent Owns Phone	0.19***	0.25***	0.04*	0.00	0.01	0.48***	0.36***	0.13***	0.01	-0.04	0.18***
Constant	0.28***	0.24***	0.01	0.03*	0.06	0.12	0.23*	0.22*	0.29***	0.47***	0.34**
R^2	0.60	0.67	0.19	0.11	0.07	0.54	0.48	0.35	0.33	0.50	0.40
Adjusted R^2	0.57	0.64	0.12	0.04	-0.01	0.50	0.43	0.30	0.27	0.45	0.35

Source: Author.

Notes: n=398. Village and ethnicity dummies not reported. HH is household. Heteroscedasticity-robust standard errors.
*p<0.05, **p<0.01, ***p<0.001.

493 Table 5. Regression Results: Determinants of Utilisation Among Phone Owners, Rajasthan

	Utilisation Index	Functional Sub-Index					
		Incoming Calls	Outgoing Calls	Incoming SMS	Outgoing SMS	Mobile Internet	Tools
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sex (Female)	-0.05	-0.02	-0.03	-0.11	-0.04	0.02	-0.09
Highest Grade	0.01**	0.00	0.00	0.03*	0.01	0.01	0.02**
Age Group	-0.02*	-0.04**	-0.03	-0.04	-0.02	0.00	-0.01
Household Size	0.01	0.01	0.01	0.02	0.00	0.01	0.00
Sex (HH Head)	0.02	-0.05	-0.07	0.00	0.02	0.09	0.13
Highest Grade (HH Head)	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Parents Living Elsewhere	-0.08*	0.02	-0.09	-0.16	-0.12	-0.03	-0.10
Spouse Living Elsewhere	0.01	-0.02	0.02	-0.02	-0.01	-0.04	0.12
Siblings Living Elsewhere	0.07	-0.06	0.05	0.13	0.06	-0.03	0.26*
Children Living Elsewhere	0.00	-0.02	-0.03	0.13	-0.04	0.01	-0.07
Wealth Index Quintile	0.00	0.04**	0.03	-0.05	-0.01	-0.01	-0.02
Mobiles per HH Member	0.26**	0.22*	0.21*	0.76***	0.03	0.08	0.26
HH Assets: Landline Phone[a]							
HH Assets: Computer	0.15	-0.01	-0.01	0.45*	0.07	0.01	0.37**
Phone Type	-0.04	-0.03	-0.01	-0.13*	-0.04	0.05	-0.06
Phone Language (English)	0.04	-0.02	-0.03	0.02	0.09	0.07	0.10
Phone Condition	0.01	0.00	0.00	0.06	0.00	-0.01	0.03
Phone Location When Outdoors (At Home)	-0.03	0.01	-0.04	-0.07	-0.03	0.01	-0.04
Phone Location When Outdoors (With Others)	-0.20***	-0.31***	-0.31***	-0.11	-0.05	-0.02	-0.40***
Years of Phone Use	0.01	0.01	0.00	0.02	0.01	0.01	-0.01
Constant	0.29*	0.55***	0.51***	0.12	0.23	0.01	0.33
R^2	0.62	0.56	0.50	0.48	0.30	0.31	0.46
Adjusted R^2	0.49	0.42	0.34	0.31	0.07	0.10	0.29

494 Source: Author.
495 *Notes: n*=168. Village and ethnicity dummies not reported. HH is household. Heteroscedasticity-robust standard errors.
496 [a]No landline phones in Rajasthan sample.
497 *p<0.05, **p<0.01, ***p<0.001.
498

Table 6. Regression Results: Determinants of Utilisation Among Phone Owners, Gansu

	Utilisation Index	Functional Sub-Index					
		Incoming Calls	Outgoing Calls	Incoming SMS	Outgoing SMS	Mobile Internet	Tools
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sex (Female)	-0.06	-0.08	-0.13*	-0.08	0.00	0.03	-0.10
Highest Grade	0.01**	0.00	0.01	0.02*	0.01	0.02**	0.02**
Age Group	-0.09***	-0.02	-0.06*	-0.08**	-0.12***	-0.14***	-0.12***
Household Size	0.01	0.01	0.01	0.00	-0.02	0.01	0.01
Sex (HH Head)	0.08	0.12	0.05	0.07	0.15*	0.01	0.10
Highest Grade (HH Head)	0.01	0.00	0.00	0.01	0.01*	0.00	0.01
Parents Living Elsewhere	-0.05	0.00	0.04	-0.08	-0.05	-0.15***	-0.03
Spouse Living Elsewhere	-0.03*	-0.02	-0.06*	0.00	0.00	-0.01	-0.07**
Siblings Living Elsewhere	-0.04	-0.07*	-0.06	-0.03	-0.02	-0.04	-0.02
Children Living Elsewhere	0.04	0.03	0.06	0.02	0.03	0.00	0.07
Wealth Index Quintile	0.02	0.00	0.03	0.04	0.04*	-0.03	0.03
Mobiles per HH Member	0.03	-0.01	0.01	0.01	0.04	0.13***	0.01
HH Assets: Landline Phone	-0.02	-0.04	-0.01	-0.10	-0.06	0.11*	-0.03
HH Assets: Computer	0.02	0.05	-0.01	0.01	-0.02	0.11	-0.01
Phone Type	0.03	0.00	0.01	0.02	0.03	0.06*	0.06
Phone Language (English)	-0.37***	-0.22***	-0.05	-0.52***	-0.26*	-0.38**	-0.76***
Phone Condition	-0.01	-0.06	0.00	0.02	-0.02	-0.02	0.05
Phone Location When Outdoors (At Home)	-0.07*	-0.13*	-0.15**	0.02	-0.04	-0.05	-0.06
Phone Location When Outdoors (With Others)	-0.22*	-0.13	-0.32	-0.24***	-0.11	-0.20	-0.32
Years of Phone Use	0.01	0.01**	0.02***	0.01	0.00	-0.01	0.01
Constant	0.38***	0.69***	0.50**	0.20	0.29	0.41**	0.22
R^2	0.54	0.29	0.35	0.32	0.37	0.60	0.39
Adjusted R^2	0.47	0.17	0.24	0.21	0.27	0.54	0.29

Source: Author.

Notes: n=265. Village and ethnicity dummies not reported. HH is household. Heteroscedasticity-robust standard errors. *p<0.05, **p<0.01, ***p<0.001.

Considering phone utilisation among the general population in Tables 3 (Rajasthan) and 4 (Gansu), two main observations emerge. First, as would be expected, personal mobile phone ownership was an important correlate of general and basic mobile phone utilisation in both sites (Models 1, 6-8), and it was linked strongly to the utilisation of own phones and shared phones (Models 2 and 3). Yet, contrary to intuition, the utilisation of other functions (e.g. incoming text messages) and through other access modes (borrowed phones, third-party access) were *independent* of personal mobile phone ownership. Second, population-level phone utilisation was also influenced by individual and social factors. For example, being female and older was negatively associated with average utilisation, whereas the relationship with education was

positive. In Rajasthan, the household size, the education of the household head, and the number of mobile phones per household member were positively correlated with a range of utilisation indicators, which suggests that phones and technical skill were shared within the household (at least for basic uses). Among the more individualistic and dispersed rural households in Gansu, these factors had very little influence on utilisation.

Tables 6 (Rajasthan) and 7 (Gansu) provide further insight into the correlates of overall and functional utilisation among phone owners, with additional mobile-phone-specific control variables (phone type, language, condition; phone location when leaving the house; years of phone use). A common pattern was the continued association of age and education with mobile phone utilisation; especially so in the more individualistic setting of rural Gansu. In addition, mobile phone utilisation tended to be significantly lower if owners left their phones at home (Gansu) or with other individuals (Rajasthan, Gansu). Differences between the sites were visible as well: In Rajasthan, the positive and significant coefficient for household mobile phone ownership suggests that social interactions and potentially technical skill within the household influenced personal phone use. In Gansu, utilisation was linked positively to the number of years of experience with mobile phone, and negatively to the phone's interface language and to family dispersion.

The qualitative data helped to explain the social drivers and frictions of mobile phone utilisation in greater depth, for instance the social context of mobile phone access and the limitations of technological learning-by-doing (on which I will focus in the remainder of this section). Firstly, mobile phone access was conditioned by site-specific logistical requirements and different "costs" to the user. For instance, respondents in both sites indicated that, in sharing arrangements between spouses, unknown callers led to "*misunderstandings*" (Gansu, woman, 42, recently lost phone) and "*a lot of stress and tension in the household and between husband and wife*" (Rajasthan, woman, 22, phone owner). Likewise, the transactional nature of

borrowing could become an obstacle for mobile phone access if it restricted phone access to "*important things*" from the lender's perspective (Gansu, man, 47, phone owner). A female respondent in a group discussion in Rajasthan described this challenge in her village:

> "*When* [women without a phone] *have to a make call, they have to go from house to house to ask people to make a call for them, and people make excuses and say that 'We don't have balance', 'My phone is not working', and so forth*". (Rajasthan, response in female focus group with mixed mobile phone ownership)

Similar difficulties were reported in Gansu, where for instance an illiterate respondent in a group discussion mentioned that, "*Sometimes* [other villagers] *wouldn't lend. They would say to be out of power or out of service*". Frictions in sharing and borrowing can therefore suppress the access to and use of mobile phones, especially for non-critical uses like browsing the mobile Internet as described above.

Secondly, my qualitative analysis did not dispute that individuals learn technical skills on their own or from other phone users. However, the evidence suggested that learning processes were incomplete because available mobile phone functions were often under-utilised and years of experience with mobile phones were not strongly related to phone utilisation. Middle-aged and older respondents indicated that younger family members taught them few skills beyond receiving and making calls, and that they might become impatient and indeed "*angry*" about repeated requests to explain basic functions of the mobile phone (Rajasthan, woman, 35, phone owner). Trial-and-error self-learning processes were similarly complicated and not only constrained by visual impairment or illiteracy, but also by economic considerations. For example, an older man in Rajasthan was reluctant to borrow a mobile phone

from his family members "*because if I press a wrong button accidently, then I will cause money loss*" (Rajasthan, men, 55 to 60 [group response], non-owners).

These patterns suggested that learning could come at a "cost" (psychic, social, and in some instances also perceived monetary costs), which had to justify the expected benefit of being able to make calls, send text messages, operate the calculator, or to use the mobile Internet. Where this was not the case, users simply stated that further functional engagement with the phone was "*unnecessary*" (Gansu, man, 60, phone owner). Economic constraints and limited formal education appeared to accentuate these limitations, which may explain the comparatively lower use of more advanced functions like text messaging and mobile data in Rajasthan: utilisation scores for incoming SMS, outgoing SMS, and mobile data in Rajasthan were 0.15, 0.05, and 0.02, compared to 0.30, 0.22, and 0.28 in Gansu.

Overall, the data analysis suggested that the utilisation of mobile phones was socially and contextually conditioned, regardless of whether people owned the device. The quantitative analysis indicated that—alongside phone ownership—education and age are consistent and important correlates of overall phone utilisation among the general populations and phone owners in both field sites. Other factors like sex and wealth varied across the local context of the rural Indian and Chinese case studies and corresponded thus to locally idiosyncratic patterns of mobile phone utilisation. The qualitative analysis provided more detailed examples of sharing arrangements and technological learning processes, all of which undermined the notion of "ubiquity" as people continued to "under-utilise" mobile devices despite their alleged diffusion.

5 Discussion and Conclusion

The purpose of this paper was to challenge widespread "ubiquity" narratives through a mixed methods exploration of the manifestations, drivers, and frictions of mobile phone use. The analysis focused on rural India and China as two low- and middle-income settings with fast

mobile phone diffusion that are likely to attract mobile-phone-based development interventions. My findings illustrated that:

(a) mobile phones were widespread in both sites;

(b) indirect routes extended phone access yet further;

(c) the nature and uses of these phones was highly heterogeneous;

(d) common demographic factors like education, age, and sex and site-specific factors like mobility patterns and living arrangements shaped the utilisation of phones systematically;

(e) indirect routes of access came with logistical requirements that could reduce non-emergency phone use in settings with low degrees of mobile diffusion; and

(f) frictions in peer learning and learning-by-doing prevented individuals from making "full use" of mobile technology in economically constrained settings with low levels of education.

Taken together, this evidence provided consistent and strong support for the claim that the notion of "ubiquity" is misleading.

However, it is worth considering three main limitations. Firstly, the study took place in rural field sites in two low- and middle-income countries. While it is possible to question the representativeness of the findings on this basis, my findings correspond to qualitative and survey research in other low-, middle-, and high-income countries (Basu & Foster, 1998; Chipchase, 2008; Dey et al., 2011; Fernández-Ardèvol, 2014; Medhi, Cutrell, & Toyama, 2010; Reisdorf, 2011), and they echo arguments of other bodies of development research, for instance the proximate illiteracy literature where literacy constraints are partially overcome through the presence of third parties (Basu & Foster, 1998; Basu et al., 2001; Iversen & Palmer-Jones, 2008; Maddox & Esposito, 2013). This degree of consistency makes it improbable that the

documented manifestations and challenges of mobile phone use are somehow wonderful phenomena of poor, rural areas of Rajasthan and Gansu.

Secondly, the quantitative data set based on a cross-sectional non-experimental stratified cluster random survey design did not allow me to rule out reverse causality conclusively. For example, a significant positive association between mobile phone utilisation and education could mean that phone users access information to learn more effectively (Aker, Ksoll, & Lybbert, 2012). While I could therefore only establish associations between the dependent and independent variables, the consistency between the quantitative and the qualitative findings and an illustrative robustness check in Supplemental File 3 using two-stage least squares estimates lent support to the argument that the control variables played a role in determining utilisation, rather than *vice versa*. Yet, the study design imposed limitations for understanding the dynamic appropriation of mobile phones, and it further limited my ability to capture the social environment of individuals comprehensively. Future research may therefore explore causal relationships and social positions in greater depth through longitudinal social network data that capture gradual mobile phone utilisation within changing socio-technical contexts together with alternative instruments or direct measures of technical literacy and affinity.

Thirdly, my phone utilisation index was only a partial representation of a multidimensional concept of "adopting" mobile technology. The index focused on general yet basic functional engagement with mobile phones, which ignores specific uses like social, economic, or healthcare applications of the phone (for examples of healthcare uses, see Haenssgen, 2015a, 2018; Haenssgen & Ariana, 2017), and it did not include symbolic forms of engagement that could be of interest in sociological research (Lee et al., 2012). The quantitative findings were therefore shaped by my construction of the utilisation variables, which exceeded variation contained in common binary indicators of mobile phone adoption. For example,

ownership-based measures of "adoption" would have assumed away any differences in usage among the 47% and 78% phone owners in rural Rajasthan and Gansu, while a binary measure based on Rogers's (2003:21) notion of "full use" (i.e. 100% phone utilisation) would have generated adoption rates of 0% in Rajasthan and 5% in Gansu. My approach, though idiosyncratic, was justified because it was grounded in preceding qualitative research that aimed to understand the varied forms of mobile phone use before measuring them quantitatively—yielding thus a more faithful representation of people's engagement with technology in rural Rajasthan and Gansu than conventional binary indicators of adoption. Future work may compare different index constructions for their analytical power in various geographic contexts (e.g. urban middle-income settings) and domains of use (e.g. employment search), and explore the degree of social (e.g. gender) stratification across various measures of mobile phone utilisation.

Bearing in mind these limitations, I have reason to believe that my claims hold—but the implication of this study is certainly not that mobile phones should be disregarded in international development. Access to technology evidently matters and no phone utilisation can occur in the absence of diffusion. My analysis rather suggests that (i) we cannot take ubiquity for granted, given that mobile phone use—like literacy—is always socially embedded and thus subject to social frictions and enablers; (ii) phone-based innovations and their benefits may diffuse unevenly along functional and social strata, given the social embeddedness of phones; and (iii) we need further conceptual and empirical work to understand the various dimensions of mobile phone adoption in particular and technology adoption in general—without projecting potentially biased notions on low- and middle-income settings. As such, effective use may be a superior indicator to nominal ownership, similar to claims that effective literacy is a superior measure to individual literacy rates (Basu & Foster, 1998). At the same time, we should be wary not to assume that externalities leading to greater digital inclusion are unambiguously advantageous because technology adoption may have also negative externalities for non-users

(e.g. by absorbing public resources at the expense of non-users, Haenssgen, 2018; Haenssgen & Ariana, 2017).

In conclusion, heterogeneous mobile phone utilisation is not an idiosyncrasy of "developing countries" because it has been documented in high- as well as low-income contexts. The continued reproduction of the "ubiquity" narrative therefore risks establishing a hollow and potentially misleading cliché of universal mobile phone inclusion. Development interventions based on such a pro-technology bias can potentially replicate or even amplify the marginalisation of those believed to benefit from diffusion processes.

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966 **Appendix**

967 Appendix Table 1. Sample Data Summary (Unweighted)

Variable		Rajasthan					Gansu				
		n	Mean	Min.	Max.	SD	*n*	Mean	Min.	Max.	SD
Dependent Variables (Mobile Phone Utilisation)											
Utilisation Index		400	0.31	0.00	0.94	(0.20)	398	0.29	0.00	1.00	(0.27)
Access Sub-Index	Own Phone	400	0.19	0.00	0.94	(0.25)	398	0.26	0.00	1.00	(0.28)
	Shared Phone	400	0.28	0.00	0.94	(0.20)	398	0.10	0.00	1.00	(0.21)
	Borrowed Phone	400	0.01	0.00	0.28	(0.04)	398	0.00	0.00	0.17	(0.02)
	3rd-Party Use	400	0.17	0.00	0.56	(0.12)	398	0.04	0.00	1.00	(0.09)
Functional Sub-Index	Outgoing Calls	400	0.65	0.00	1.00	(0.32)	398	0.55	0.00	1.00	(0.39)
	Incoming Calls	400	0.64	0.00	1.00	(0.31)	398	0.45	0.00	1.00	(0.40)
	Outgoing SMS	400	0.13	0.00	1.00	(0.31)	398	0.20	0.00	1.00	(0.35)
	Incoming SMS	400	0.04	0.00	1.00	(0.15)	398	0.12	0.00	1.00	(0.28)
	Mobile Internet	400	0.02	0.00	1.00	(0.11)	398	0.11	0.00	1.00	(0.29)
	Tools	400	0.35	0.00	1.00	(0.40)	398	0.30	0.00	1.00	(0.41)
Control Variables for Mobile Phone Utilisation Among General Population											
Sex (Female)		400	0.55	0.00	1.00	(0.50)	398	0.59	0.00	1.00	(0.49)
Highest Grade		400	3.21	0.00	18.00	(4.34)	398	4.09	0.00	15.00	(4.13)
Age Group		400	3.02	1.00	5.00	(1.33)	398	3.96	1.00	5.00	(1.15)
HH Size		400	5.24	1.00	15.00	(2.20)	398	3.16	1.00	15.00	(1.69)
Sex (HH Head)		400	0.07	0.00	1.00	(0.26)	398	0.10	0.00	1.00	(0.30)
Highest Grade (HH Head)		400	3.39	0.00	18.00	(4.09)	398	5.22	0.00	25.00	(3.90)
Parents Living Elsewhere		400	0.07	0.00	1.00	(0.25)	398	0.24	0.00	1.00	(0.43)
Spouse Living Elsewhere		400	0.03	0.00	1.00	(0.18)	398	0.16	0.00	9.00	(0.56)
Siblings Living Elsewhere		400	0.10	0.00	1.00	(0.29)	398	0.70	0.00	1.00	(0.46)
Children Living Elsewhere		400	0.09	0.00	1.00	(0.28)	398	0.64	0.00	1.00	(0.48)
Wealth Index Quintile		400	2.83	1.00	5.00	(1.41)	398	2.65	1.00	5.00	(1.35)
Mobiles per HH Member		400	0.21	0.00	1.00	(0.19)	398	0.61	0.00	5.00	(0.45)
HH Assets: Landline		400	0.00	0.00	0.00	(0.00)	398	0.20	0.00	1.00	(0.40)
HH Assets: Computer		400	0.01	0.00	1.00	(0.10)	398	0.12	0.00	1.00	(0.32)
Respondent Owns Phone		400	0.43	0.00	1.00	(0.50)	398	0.67	0.00	1.00	(0.47)
Additional Control Variables for Analysis of Mobile Phone Utilisation Among Phone Owners											
Phone Type		168	1.35	0.52	1.00	(3.00)	267	1.80	0.85	1.00	(3.00)
Phone Language (English)		168	0.24	0.43	0.00	(1.00)	267	0.01	0.09	0.00	(1.00)
Phone Condition		168	1.18	0.56	1.00	(4.00)	267	1.57	0.59	1.00	(4.00)
Phone Location (At Home)		171	0.24	0.43	0.00	(1.00)	267	0.15	0.36	0.00	(1.00)
Phone Location (w/ Others)		171	0.08	0.27	0.00	(1.00)	267	0.01	0.11	0.00	(1.00)
Years of Phone Use		171	4.31	2.68	0.00	(18.00)	265	5.92	3.90	0.00	(20.00)

968 Source: Author.

969 *Note.* Two questionnaires in Gansu were invalid and were dropped from the analysis. SD is standard deviation. HH is
970 household.

971 Appendix Table 2. Variable Description

Variable		Description
Dependent Variables (Mobile Phone Utilisation)		
Utilisation Index		Simple average of six phone functions (see below), with index values ranging from 0 (less than monthly use of *any* of the six phone functions across any access mode) to 1 (daily or more frequent use of *all* six phone functions across any access mode).
Access Sub-Indexes (Own Phone / Shared Phone / Borrowed Phone / 3rd-Party Use)		Use of four individual mobile phone access routes: through the respondent's own phone, a shared phone, a borrowed phone, or through a third party (which can include own or others' phones). Calculate as simple average utilisation of six phone functions (see below) used through each access mode, where each function is scored as follows: 1 – daily use; 2/3 – weekly use, 1/3 – monthly use, 0 – less frequent use
Functional Sub-Indexes (Outgoing Calls / Incoming Calls / Outgoing SMS / Incoming SMS / Mobile Internet / Tools)		Use of six individual mobile phone functions: outgoing calls, incoming calls, outgoing SMS, incoming SMS, mobile Internet, and tools (irrespective of mode of access). Each function scored according to maximum frequency of use across the four different access modes with following values: 1 – daily use; 2/3 – weekly use, 1/3 – monthly use, 0 – less frequent use.
Control Variables for Mobile Phone Utilisation Among General Population		
Personal$_i$ Characteristics	Sex (Female)	Dummy variable: 0 – male; 1 – female
	Highest Grade	Highest completed grade of formal education
	Age Group	Ordinal variable: 1 – 18-24 years; 2 – 25-34 years; 3 – 35-44 years; 4 – 45-59 years; 5 – 60+ years
	Wealth Index Quintile	Continuous variable: Number of functioning mobile phones in a household divided by the number of household members
	Ethnicity (not reported)	Dummy variable: Respondent's ethnic group
Social$_{ii}$ Environment	Household Size	Continuous variable: Number of people who share kitchen and have resided in the house for more than six months
	Sex (Household Head)	Dummy variable: 0 – male; 1 – female
	Highest Grade (Household Head)	Continuous variable: Highest completed grade of formal education
	Parents/Spouse/Siblings/Children Living Elsewhere	Dummy variable: 0 – respondent does not have a parent/spouse/sibling/child who lives outside the village; 1 – all other cases (not counting parents-in-law and siblings-in-law)
Technical$_i$ Environment	Mobiles per Household Member	Ordinal variable: 5 wealth quintiles calculated separately for each country using principal component analysis of 19 household assets and amenities
	Household Assets: Landline	Dummy variable: 0 – household does not own a functioning landline telephone; 1 – household owns a functioning landline telephone
	Household Assets: Computer	Dummy variable: 0 – household does not own a functioning computer or laptop; 1 – household owns a functioning computer or laptop
	Respondent Owns Phone	Dummy variable: 0 – respondent does not personally own a mobile phone; 1 – respondent personally owns a mobile phone
Contextual$_i$ Factors		Dummy variable for each of the 32 villages (in addition to stratified analysis by country)
Additional Control Variables for Analysis of Mobile Phone Utilisation Among Phone Owners		
Technical$_i$ Environment	Phone Type	Ordinal variable: 1 – "basic phone"; 2 – "feature phone"; 3 – "smartphone" (assessed using show card)
	Phone Language (English)	Dummy variable: 0 – local language; 1 – English
	Phone Condition	. Ordinal variable: 1 – "good condition"; 2 – "signs of wear and tear"; 3 – "significant damage"; 4 – "not working" (assessed using show card)
	Phone Location When Outdoors (At Home)	Dummy variable: 0 – "the mobile phone is with me when I am outdoors"; 1 – "the mobile phone is at home when I am outdoors"
	Phone Location When Outdoors (With Others)	Dummy variable: 0 – "the mobile phone is with me when I am outdoors"; 1 – "the mobile phone is with other people when I am outdoors"
	Years of Phone Use	Continuous variable: Number of years since first mobile phone use

972 Source: Author.
973

[i] Aggregate result of search queries '"mobile phones have become ubiquitous" | "mobile phones are now ubiquitous" | "mobile phones are ubiquitous"' (61,800 results), '"cell phones have become ubiquitous" | "cell phones are now ubiquitous" | "cell phones are ubiquitous"' (53,200 results), and '"smartphones have become ubiquitous" | "smartphones are now ubiquitous" | "smartphones are ubiquitous"' (18,100 results) on May 23, 2016. Other combinations of ranged from 16,000 to 42,800 results each.

[ii] I thank the Editor for bringing this point to my attention.

[iii] The research was approved by the Oxford Department of International Development's Departmental Research Ethics Committee (Ref. SSD/CUREC1A/13-199 and CUREC1A/ODID C1A 14-031), by the Gansu Province Department of Statistics (Ref. 2013/10 and 2014/8), and by the internal ethics commission of the Indian Institute of Health Management Research, Jaipur.