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Do mobile phones empower women?
A perspective from rural India

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"*We are very happy to introduce the Warwick Monash Economics Student Papers (WM-ESP). The Department of Economics of the University of Warwick and the Economics Department at Monash University are very proud of their long history of collaboration with international partner universities, and the Monash Warwick Alliance reflects the belief in both Universities that the future will rely on strong links between peer Universities, reflected in faculty, student, and research linkages. This paper series reflects the first step in allowing our Undergraduate, Honours, and Masters students to learn from and interact with peers within the Alliance.*"

Jeremy Smith (Head of the Department of Economics, University of Warwick) and Michael Ward (Head of the Department of Economics, Monash University)

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Do mobile phones empower women?
A perspective from rural India.

Jingjing Chen[*]

Abstract

Empowerment for girls and women, Goal 5 for the Sustainable Development Goals, is the key for economic development. As mobile phones become cheaper and more prevalent, a growing number of researchers are investigating their impact on women's empowerment. Most previous research has relied on interviews and cross-sectional data, so their conclusion limited to the association rather than establishing the causal relationship between mobile phones and female empowerment. This paper used Indian Human Development Survey 2005 and 2011-2012 to study the association between mobile phone ownership and women's empowerment in rural India. Then difference-in-difference strategy was applied to identify the causal impact of village mobile phone service installation on female empowerment. Like previous studies, the results from this paper suggest that mobile phone ownership was associated with higher women's empowerment. Moreover, mobile phone service installation increased women's involvement in decision-making process but it decreased female labour force participation and contraceptive usage in rural India.

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1 Introduction

As Goal 5 for the Sustainable Development Goals (SDGs)(United Nations, 2015), empowerment for girls and women is the key for achieving other SDGs such as achieving food security and improving health (Thomas, 1993, 1990). Moreover, women's empowerment drives economic growth, as Cuberes and Teignier (2016) found gender inequality in the labour market can reduce average income for OECD countries by 15.4 percent and 17.5 percent for developing countries in the long run. In India, the progress of gender equality is disappointing, compared to its rapid economic growth. For instance, its child mortality is 11 percent higher for girls than boys, while globally it is 9 percent higher for boys[*]. Likewise, situation does not improve for adult women in India, where 27 percent of women aged 20 to 24 were married before 18[†], with 7,727 dowry deaths in 2018[‡].

Kabeer (1999) defined women's empowerment as the process by which women gain their denied ability to make strategic choices. The review paper by Kabeer (2005) has shown that education, paid work and political participation improve women's self-respect, independence and cognitive abilities. This makes these resources the important tools which empower women, and potentially change the attitude of Indian women who think it is justified for men to beat their wives under some circumstances like bad cooking[§]. By using internet on mobile phones, women can access these resources more easily, such as learning through YouTube videos, finding jobs through online job boards and expressing political views via Twitter. Moreover, mobile phones provide women with a more private access to information than TV, which empowers women, such as lowering their son preference through observing others lives from TV (Dasgupta, 2019). Mobile phones also have the potential to raise women's financial independence, as Swain and Wallentin (2009) found mobile money facilitates microfinance programme which supports female entrepreneurs and helps them become independent.

The benefit of female empowerment on economic and social development makes it important for policymakers to understand the impact of mobile phones on female empowerment, so they can design relevant policies accordingly. While a growing number of papers have begun to use empirical strategies, such as instrumental variables (IV) estimation and fixed-effect models, to investigate the association or causality between mobile phones and female empowerment, many relevant studies used qualitative methods, such as focus groups and interviews. This paper aimed to continue the quantitative study on the association between mobile phones and women's empowerment. Ordinary Least Squared (OLS) analysis was firstly used to investigate the association between mobile phone ownership and women's empowerment. Then an attempt to identify the causality was made via difference-in-difference strategy, to study the causal effect of mobile phone service installation on women's empowerment in rural India.

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[*]Office of the Registrar General and Census Commissioner (India) (2016)
[†]International Institute for Population Sciences (IIPS) and ICF (2017)
[‡]National Crime Record Bureau Ministry of Home Affairs (2018)
[§]International Institute for Population Sciences (IIPS) and ICF (2017)

This paper investigated five key aspects of women's empowerment: fertility choice and knowledge, financial independence, political awareness, decision-making power and freedom of movement. The hypothesis is that mobile phone ownership and mobile phone service installation empowered women so that they had better fertility choice and knowledge, greater financial independence, greater political awareness, higher decision-making power and higher freedom of movement.

The empirical strategy in this paper relied on the panel data from Indian Human Development Survey 2005 (IHDS) and 2011-2012 (IHDS-II), which are national representative. Using cross-sectional data from IHDS-II, the results of OLS analysis indicate that mobile phone ownership was associated with higher HIV/AIDS awareness and financial independence. Mobile phone owners also had greater freedom of movement to health centres and greater participation and power in decision-making. The identification assumption for difference-in-difference strategy is the parallel trend that individuals in the treatment villages would have followed the same trend as those in the control villages, if the mobile phone service had not installed in the treated villages. The results of difference-in-difference strategy indicate that mobile phone service installation led to a preference of a smaller family size, a higher chance to have cash in hand and greater involvement in decision-making process. However, it also unexpectedly correlated with lower contraceptive usage and lower work participation.

2   Literature Review

A growing number of recent papers have examined the impact of mobile phones on women's empowerment using different indicators for empowerment. One indicator used is freedom of movement, which could be improved by using mobile phones as they provide the flexibility to reach people anytime and anywhere. For instance, Tacchi et al. (2012) also found some mothers were able to participate in the job market because it is easier for them to monitor their children's safety over the phone. On the safety side, Nasar et al. (2007) found college girls would only go to certain places when they had mobile phones with them. However, Tacchi et al. (2012) also found mobile phones have lowered freedom of movement for some women, as their husbands did not allow them to visit their parents, when communication became easier and more frequent via mobile phones.

Entrenched social norms in patriarchal societies may undermine the effects of mobile phone on freedom of movement, but mobile phones can still empower women who have limited freedom, by providing them with the access to useful information. For instance, Hoan et al. (2016) interviewed 26 Vietnamese foreign brides in Singapore and found mobile phones help them learn local culture and conduct home-based businesses, when their movement was restricted by housework and childcare. Similarly, Aminuzzaman et al. (2003) also found mobile phones offered an easier access to the latest market information under the Village Phones scheme in Bangladesh. By increasing economic activities and income, mobile

phones could help women gain financial independence and self-confidence, which could lead to higher household decision-making power. Nevertheless, not all information accessed is empowering women. Vietnamese foreign brides also used mobile phones to gain information for 'essentialization' initiative, so they can balance their aspiration and idealised motherwood and wifehood. While this leads to higher marital satisfaction, Hoan et al. (2016) argues it also reinforces gender inequality. However, this finding was based on 26 Vietnamese foreign brides who faces multiple grounds of discrimination from gender, ethnicity and social class, which makes it not general and hard to apply to other female groups.

Most related researches, especially for India were qualitative, conducted through interviews and focus groups. One quantitative research was recently done by Mohan et al. (2020) , who found mobile phone ownership was associated with greater utilization of health service including modern contraceptives in urban areas but not in rural areas of India. Yet, these results cannot be interpreted as causality due to the nature of cross-sectional data. To solve the problem of endogeneity and reverse causality, Rotondi et al. (2020) carried out IV estimation using local lightening flash rates and local mobile phone coverage as instruments for mobile phone ownership. They found that mobile phone ownership led to higher probability of knowing HIV test locations and greater contraceptive uses, and an increase in women's decision-making power in Sub-Saharan African countries. They also found that mobile phone ownership had the greatest impact on the most vulnerable women, consistent with the findings of Mohan et al. (2020), which state that mobile phones have a greater, but not statistically significant, impact on postpartum care and the use of modern contraceptives among the poorest women.

Another method to find the casual effect is to use panel data. For instance, Billari et al. (2020) used fixed effect model and found that women who owned mobile phones in Malawi prefer small family size and have lower parity (number of children ever born), due to the role model effect of observing others' lives through mobile phones. Furthermore, they found it was the use of internet and mobile money leading to preference for smaller family size, and internet use leads to lower parity, with no effect from making calls.

In spite of these positive impacts, many papers also found no effect or even negative effects of mobile phones on women's empowerment and well-being. For example, mobile phones were used for surveillance of women, and they also increased sexual harassment through spread of pornography and sexting in sub-Saharan (Porter et al., 2020). Meanwhile, existing stereotype and social norms may stop women using mobile phones. Some midwives in Indonesia, for instance, felt it inappropriate to use mobile phones in their social status, even they are using mobile phones for emergency service in hospitals (Chib and Chen, 2011). As Porter et al. (2020) argued, policies regarding mobile phones need to consider the local context and culture. Otherwise they could reinforce or exacerbate existing gender inequality.

The main contribution of this paper is to identify the casual effects of mobile phone service installation on women's empowerment in rural India. To my best knowledge, this causal relationship for India has not been studied so far. Besides, this paper investigated

the impact from five aspects of women's empowerment. As Tacchi et al. (2012) argues that mobile phones could empower women in one way but exacerbate existing tensions in other aspects, it is useful to investigate mobile phones' impact from different dimensions.

3   Methodology

The first empirical strategy is to identify the impact of mobile phone ownership on women's empowerment by controlling observable characteristics of individual women, using OLS regressions with controls. This strategy assumes all unobserved characteristics are uncorrelated with mobile phone ownership. The OLS regression used is following,

$$y_{ij} = \beta_0 + \beta_1 * MP_{ij} + X\beta + c_j + \epsilon_{ij} \tag{1}$$

where y_i represents the outcome variables for women's empowerment of individual i in village j; MP_{ij} indicates mobile phone ownership, so $MP_{ij} = 1$ if individual i owns a mobile phone, and zero otherwise; X is a vector of control variables, c_j is the village-level fixed effects and ϵ_{ij} is the disturbance term. β_1 is the coefficient of interest that measures the impact of mobile phone ownership on women's empowerment.

Control variables include demographic factors such as age, education, religion and caste. Exposure to mass media such as TV and radio is found to empower women, so they are also controlled (Dasgupta, 2019). Educated men might respect wives more so their wives are likely to have higher decision-making power and freedom of movement. Therefore, spouse's family backgrounds such as his education level and family size are also controlled. Women's belief and empowerment is likely to be affected by their environment so village-level fixed effects is added. Variables such as 'whether it is permissible to marry girls to their cousin in the community' are also added as control to capture the community belief and practice, which could potentially impact women's empowerment. Although these observable variables are controlled, OLS analysis could face still face endogeneity problem. Firstly, there could be omitted variable bias due to unobserved variables. Secondly, there could be reverse causality that empowered women with higher decision-making power and financial independence are more likely to buy mobile phones.

As there is endogeneity problem with OLS regressions, difference-in-difference strategy was then used to identify the causal effect of mobile phone in terms of mobile phone service installation. As the mobile phone installation is at village level, an individual's empowerment level is unlikely to have impact on the decision and timing of this service installation. Thus, the reverse causality problem is mitigated here. If mobile phone service has any impact on women's empowerment, it must reflect the impact of mobile phones.

As mobile phone service was rolled out in India, the mobile phone service impact can be measured by comparing the change of women's empowerment in treated villages against the change in control villages. The identification assumption is that individuals in treated

villages would have followed the same trend as those in control villages if the mobile phone service was not installed in the treated villages. Treated villages are those that got mobile phone service installation in the time between IHDS and IHDS-II. Control villages are those that had mobile phone service for more than two years by the time of IHDS. The two-years window allows any lag effect of mobile phone service to materialise, as it may take time for people to learn how to use mobile phones. This allows me to assume that these control villages would be a good counterfactual for treatment villages, as by the time of first survey, the effect of mobile phone service was fully materialised and the trend of control villages recovered from divergence and parallel to the trend of treatment villages.

The regression for difference-in-difference strategy is following,

$$y_{ijt} = \beta_1 + \beta_2 * Post_t + \beta_3 * Treat_j * Post_t + X\beta + c_j + \epsilon_{ijt} \tag{2}$$

where y_{ijt} is the outcome variables for individual i, in village j at time t. $Post_t = 1$ if in 2005 and 0 if in 2011/2012. Hence, β_2 measures the common shocks. X includes the control variables. $Treat_j = 1$ if village j is the treated village and zero if it is control village. c_j is the village-level fixed effects and ϵ_{ijt} is the disturbance term. β_3 is the coefficient of interest, that captures the causal effect of mobile phone service installation.

4   Data

The empirical analysis in this paper relies on panel data from India Human Development Survey in 2005 (IHDS) and in 2011-2012 (IHDS-II). India Human Development Survey (IHDS) interviewed 42,152 households in 1,503 villages and 971 urban neighbourhoods, using stratified random sampling. 83 percent of these original households were re-interviewed in IHDS-II. Both surveys cover all states and union territories of India with the exception of Andaman/Nicobar and Lakshadweep. The surveys cover a range of topics such as marriage, gender relations and fertility with a range of variables that could be used as measurements for women's empowerment. This makes it a good dataset for this research purpose. The feature of panel data also allows me to study the causal impact of mobile phone service installation using difference-in-difference strategy.

Eligible women panel dataset was merged with datasets for individuals, households, and villages to obtain useful variables. All outcome variables are from eligible women surveys, which were answered by women who aged 15-49 and ever married in IHDS[¶]. As information of mobile phone service is only available for rural areas from village surveys, I dropped any observations without village information[‖]. This implies both effects of mobile phone ownership and mobile phone service installation are for women in rural India. Only IHDS-II

[¶]In IHDS-II, the same eligible woman in each household were re-interviewed regardless of their age. Some women who were not eligible also completed the survey so maximum age in the dataset is 70.

[‖]This includes all observations for women from urban areas and some rural women's observations which have no corresponding village information.

was used for investigating the effect of mobile phone ownership as the question about mobile phone ownership was only asked in IHDS-II, which includes 16,603 observations.

The basic summary statistics about respondents and villages are provided in Table 1, using observations from both surveys. Table 1 shows respondents have an average of 3.1 years of schooling and an average age of 36.5. Their spouses are more educated, with an average of 5.56 years of schooling. 22 percent of respondents are poor with per capita household expenditure below 2012 Tendulkar poverty line. Out of 30 household assets asked, respondents have average 12 assets and 42 percent of them have telephones at home. Both annual household incomes and expenditures vary greatly across households. In IHDS-II, about 35 percent of respondents had mobile phones. Out of them, only 1 percent of them used internet or emails on mobile phones and 15 percent of them used SMS. For village characteristics, on average 73 percent of households in villages have electricity. About 33 percent of respondents have a saving group at their villages and 70 percent have a Self Help Group.

Summary statistics for outcome variables are shown in Table 2. For fertility knowledge and choice indicator, four variables were used. The first one is 'heard of HIV/AIDS' and the data reveals that less than 50 percent of respondents ever heard of AIDS/HIV. The second one is 'contraceptive usage' and 70.2 percent of respondents reported they were currently using some methods to delay and prevent pregnancy. The third variable is 'the ideal number of children' with an average value of 2.559. The last one is 'son preference', measured by the difference of the ideal number of sons and the ideal number of daughters. In the sample, more sons are preferred and the average value of son preference is 0.318.

Financial indicator includes four variables: 'have a bank account', 'have cash in hand' , 'work participation' and 'expenditure discussion'. Table 2 reveals that about 65 percent of respondents worked for the family farm, the family business, salaried work, agricultural wage labour, and non-agricultural wage labour. This variable does not include work with household animals. About 90 percent of respondents discuss expenditure with husbands sometimes or often, and 86.8 percent of respondents have cash in hand for household expenditure. However, only 25.7 percent of them have a bank account. For political awareness, variable 'politics discussion' is used, which measures 'how often respondents talk with husband about the things happens in the community, such as elections and politics'. About half of those surveyed discuss politics with their husbands sometimes, and about 20 percent do so regularly.

For decision-making power, I looked at 'whether respondents have a say in decisions-makings' and 'whether respondents have the most say in these decision-makings'. Five decisions were investigated and they are: 'what to cook on a daily basis', 'whether to buy an expensive item such as a TV or fridge', 'how many children respondents have', 'what to do if a child falls sick' and 'to whom respondents' children should marry'. Table 2 shows that majority of respondents have a say in these decisions, but few of them have the most say in these decisions except cooking. For example, although 85.6 percent of them have a say in

Table 1: Summary statistics for panel data

Demographic statistics

	Mean	SD	No. of observations
Age	36.46	9.01	33206
Years of schooling	3.10	4.01	33202
Spouse's years of schooling	5.56	4.61	31155
Hindu (Y=1, N=0)	0.84	0.36	33205
Poor (Y=1, N=0)	0.22	0.41	33193
No. of assets (out of 30)	11.55	5.67	33201
Have a telephone (Y=1,N=0)	0.42	0.49	33173
Household income (In Rupees)	94,662.75	163,042.03	32721
Household expenditure (In Rupees)	99,273.99	97,480.10	33193
MP ownership (Y=1, N=0)	0.35	0.48	16603
Use internet/email on MP(Y=1,N=0)	0.01	0.12	5720
Use SMS on MP (Y=1, N=0)	0.15	0.35	5713

Village statistics

	Mean	SD	No. of observations
Village area (in Hectares)	816.70	984.06	32990
Number of households	593.19	797.27	33102
Percent of households with electricity	73.25	30.82	32770
No. of years with telephone service	8.44	10.24	32795
Have a Saving group (Y=1, N=0)	0.33	0.47	32884
Have a Self Help Group	0.70	0.46	32873

Note: These summary statistics are calculated for observations from both surveys, IHDS and IHDS-II. No. of observations vary for each variable as there are some missing values and valid blank. All statistics are calculated on valid observations. Variables assets, household income and household expenditure are constructed by IHDS survey. MP ownership was only measured in IHDS-II so summary statistics are only for the 16,603 observations in IHDS-II. For variables 'use internet/email on MP' and 'use SMS on MP', the means and standard deviation were calculated for individuals who owner MP only. Some individuals did not give answers for internet/email or SMS use so the observations used are fewer than the number of MP owners.

Table 2: Dependent variables descriptive statistics

	Mean	SD	No. of observations
Dependent variables statistics			
Heard of AIDS/HIV (Y=1, N=0)	0.476	0.499	33031
Contraceptive usage (Y=1, N=0)	0.702	0.457	30306
Ideal number of children	2.559	1.000	31263
Son preference	0.318	0.678	28942
Have a bank account (Y=1, N=0)	0.257	0.437	32966
Have cash in hand (Y=1, N=0)	0.868	0.338	33144
Work participation (Y=1, N=0)	0.647	0.478	33101
Expenditure discussion (proportion):			
Never	0.102	0.303	32267
Sometimes	0.400	0.490	32267
Often	0.498	0.500	32267
Politics discussion (proportion):			
Never	0.329	0.470	32255
Sometimes	0.472	0.499	32255
Often	0.199	0.399	32255
Have a say in decision about (Y=1, N=0):			
Cooking	0.945	0.228	33180
Purchase	0.747	0.435	33070
No. of children	0.856	0.351	32403
Child sick	0.880	0.325	32127
Child marriage	0.838	0.368	31789
Have most say in decision about (Y=1, N=0):			
Cooking	0.736	0.441	33047
Purchase	0.108	0.310	32918
No. of children	0.209	0.407	31963
Child sick	0.290	0.454	32306
Child marriage	0.116	0.321	32117
Need permission to go to (Y=1, N=0):			
Health centre	0.789	0.408	33036
Kirana shop	0.574	0.494	27233
Friend's home	0.733	0.442	32848
Can go alone to (Y=1, N=0):			
Health Centre	0.686	0.464	32545
Kirana shop	0.773	0.419	29527
Friend's home	0.745	0.436	32189

Note: These summary statistics are calculated for observations from both surveys, IHDS and IHDS-II. No. of observations vary for each variable as there are some missing values and valid blank. All statistics are calculated on valid observations.

the number of children to have, only 20.9 percent of respondents have the most say in it.

Freedom of movement is captured by 'whether respondents need to ask permission to go to health centre, friend's home and Kirana shop', and 'whether respondent can go to these three places alone'. The data suggests the freedom to go to health centre is the lowest with 78.9 percent of individuals needing a permit and only 68.6 percent being able to go alone. The freedom to Kirana shop is the highest, but still 57.4 percent of respondents need to ask permission and 77.3 percent can go there alone. The freedom to friend's home is intermediate, in terms of both permission requirement and possibility to go alone.

Comparison between mobile phone owners and non-mobile phone owners was made, presented in Table 3. These two groups are statistically different in many characteristics. For instance, mobile phone owners are younger with extra 2.8 years of schooling. They are also richer with more household assets and more likely to own telephones. For community marriage practice, it was less likely to be permissible to marry girls to their cousins in the communities of mobile phone owners. However, lower proportion of mobile phone owners reported it is permissible for widows in their community to remarry, compared to the community of non-mobile phone owners.
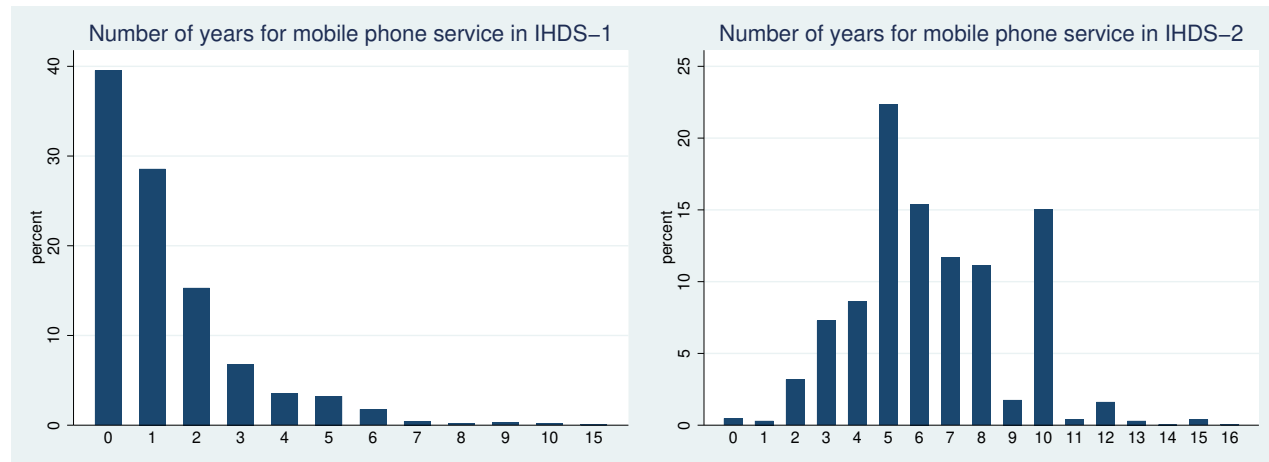
Table 3: Summary statistics for MP owner and Non-MP owner

	MP owners	Non-MP owners	Yes - No	N
Age	38.528	40.944	-2.417***	16603
Years of schooling	4.968	2.174	2.794***	16603
Spouse's years of schooling	7.232	4.688	2.544***	15370
Poor (Y=1, N=0)	0.129	0.232	-0.104***	16598
No. of assets (out of 30)	15.294	12.140	3.154***	16598
Have a telephone (Y=1, N=0)	0.827	0.684	0.143***	16598
Whether it is permissible in community (Y=1, N=0):				
To marry a girl to her cousin	0.318	0.400	-0.082***	16553
For widows to remarry	0.622	0.645	-0.022***	16337

Note: These summary statistics are calculated using data from IHDS-II survey. All statistics are only calculated on valid observations only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 1 shows the distribution of mobile phone service availability in both surveys. It is clear to see from Figure 1a that mobile phone service was rolled out across India and most villages got their mobile phone service for one or two years by the time of IHDS. As Figure 1b shows, few respondents still did not have mobile phone service in their villages by IHDS-II. Therefore, villages that already got mobile phone service before IHDS are used as controls. In this paper, only villages with more than 2-years availability in mobile phone service are used as control group, to take the potential lagged effect of mobile phone services into account. This leaves 5,824 observations to be used as controls. The treatment group are those who got mobile phone service at the time period between two surveys. In total,

18,306 observations were used for difference-in-difference strategy.

(a) Mobile phone service years in IHDS-I   (b) Mobile phone service years in IHDS-II

Note: The spike in 10 years in Figure 1b could be caused by the duration of interview periods.

Figure 1: Distribution for mobile phone services years

Baseline characteristics for treatment and control group are compared and shown in Table 4. The data indicates that treatment group was significantly different from control group for both individual and village characteristics. Firstly, respondents in treated village were younger with lower schooling for both themselves and their spouses. Treated individuals were also 15 percentage point more likely to live under poverty line with fewer household assets. This wealth difference can be partly explained by the differences in village characteristics. Treated villages are less developed than control villages. The wage level and rice price level were lower in treated village. On average, only 57 percent of households in treated villages have electricity but 86 percent for control villages. Treated villages were also more likely to have a Self Help Group but less likely to have a saving group.

The differences between treatment and control groups imply that the timing of mobile phone service installation and the treatment status were not random. Rich villages and those which are close to district headquarters are more likely to receive mobile phone service earlier, as service providers would expect people in these areas are more likely to afford mobile phones, generating fast return. Thus, village-level fixed effects were added to the difference-in-difference regression to control time invariant factors of villages that affected both women's empowerment and mobile phone service installation.

To ensure that significant results are not due to the large number of outcome variables used, data reduction method called 'principal component analysis' was used. Eight principal components were created from 24 outcome variables. The loadings for components are shown in Table A2. OLS and difference-in-difference analysis were also conducted using these components as robust checks.

Table 4: Baseline characteristics for treatment and control group

	Treatment	Control	T-C	N
Individual characteristics				
Age	32.644	33.058	-0.414**	9153
Years of schooling	2.512	3.764	-1.252***	9150
Spouse's years of schooling	4.936	6.306	-1.369***	8730
Poor (Y=1, N=0)	0.310	0.154	0.156***	9147
No. of assets (out of 30)	8.089	12.514	-4.425***	9153
Have a telephone (Y=1, N=0)	0.052	0.166	-0.114***	9133
Whether it is permissible in community (Y=1, N=0):				
To marry a girl to her cousin	0.392	0.237	0.155***	9126
Village characteristics				
Percent of households with electricity	57.591	85.959	-28.368***	9153
No. of years with telephone service	4.014	12.115	-8.101***	9105
Distance from district headquarter	54.206	34.875	19.331***	9153
Have a Self Help Group (Y=1, N=0)	0.655	0.490	0.164***	9153
Have a Saving Group (Y=1, N=0)	0.369	0.403	-0.034***	9153
Sowing wage	55.780	90.518	-34.738***	8651
Harvest wage	52.096	86.479	-34.382***	8653
Rice price	10.714	11.916	-1.203***	9105
Sugar price	14.403	13.783	0.620***	9029
Wheat price	8.271	8.197	0.074*	8960

Note: These summary statistics are calculated using data from IHDS survey. All statistics are calculated on valid observations only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5 OLS results

The OLS results are shown in Table 5 - 9. Model (1) for all outcome variables are simple OLS regression with no controls and model (2) are regressions with control variables and village-level fixed effects. Table 5 indicates that mobile ownership significantly increased the probability to know HIV/AIDS by 21.9 percentage point, which is a large increase. After adding controls, it falls to 5.5 percentage point but still statistically significant. Age has no impact on HIV/AIDS awareness but higher schooling is associated with higher awareness. Higher exposure to TV is also found useful for raising HIV awareness, but no impact from radio exposure. Poor respondents also have lower HIV/AIDS awareness. Mobile phone ownership is associated with higher contraceptive usage and lower ideal number of children, but these relationships are insignificant when controls are added.

Model (1) and (2) in Table 6 have the same specifications as models in Table 5, but the coefficients of other control variables are not presented here. The results reveal that mobile phone ownership is associated with higher financial independence in terms of a significantly higher probability of having a bank account and a marginally higher chance to have cash in hand. However, there is no correlation between mobile phone ownership and son preference, work participation, expenditure discussion and politics discussion after adding controls.

Table 7 indicates that mobile phone ownership increases freedom of movement but only significant for movement to health centre. Mobile phone owners are 3 percentage point more likely to be allowed to go to health centres alone and without the need to ask permission. The significant coefficients for health centre may indicate that mobile phones help increase women's freedom of movement when the movement was previously restricted due to safety reasons. However, when female's journey is for social rather than for necessary activities and previous restriction on movement is not due to safety concern but social norms, mobile phone has no impact on freedom of movement. This is consistent with Tacchi et al. (2012)' finding that mobile phones increased freedom to work but reduced female's freedom to visit parents.

Table 8 and 9 indicates that women with mobile phones have higher decision-making power, consistent with Rotondi et al. (2020)'s finding. More specifically, mobile phone owners are more likely to get involved in the decision-making process for the number of children to have, what to do when their children are sick and children's marriage. They are also have a higher probability to have the most says in these decision making, except for children's marriage.

Overall, although not all effects are significant, Table 5-9 indicates that MP ownership does empower women, especially in the financial independence and decision-making aspect**. By using principal components, Figure A1 also shows these significant results are not due to data mining. Nevertheless, it is difficult to interpret these results are causality as the OLS estimates are likely to be biased even with controls, due to omitted variables and reverse causality.

6 Results for difference-in-difference

The results for difference-in-difference strategy are shown in Table A4 - A6. Coefficients of Treat*Post capture the effect of mobile phone service installation on women's empowerment, which were also plotted in Figure 2. Figure 2 shows that mobile phone service installation led to a preference for fewer children, with the ideal number of children decreasing by 0.143. It also increases the likelihood of having a cash in hand by 6 percentage point. However, it reduced the use of contraception and work participation by 7.8 percent

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**Logit models are also used as robust check for binary outcome variables. Results are shown in Table A3.

Table 5: OLS results fertility knowledge and choice

	(1)	(2)	(1)	(2)	(1)	(2)
	Heard of HIV/AIDS		Contraceptive usage		Ideal number of children	
Own MP	0.219***	0.055***	0.064***	0.007	-0.259***	-0.022
	(0.012)	(0.009)	(0.009)	(0.009)	(0.023)	(0.020)
Age^2		-0.000*		-0.000***		0.000
		(0.000)		(0.000)		(0.000)
Age		0.000		0.032***		0.020**
		(0.003)		(0.004)		(0.008)
Years of schooling		0.033***		0.000		-0.025***
		(0.002)		(0.002)		(0.003)
Poor		-0.021**		0.046***		0.198***
		(0.010)		(0.010)		(0.025)
TV (sometimes)		0.011		0.008		0.039
		(0.010)		(0.012)		(0.028)
TV (regularly)		0.032***		0.017		-0.009
		(0.012)		(0.011)		(0.027)
Radio (sometimes)		0.013		0.022*		-0.056*
		(0.011)		(0.012)		(0.029)
Radio (regularly)		0.005		-0.001		-0.085*
		(0.019)		(0.019)		(0.045)
Constant	0.426***	0.283***	0.771***	0.041	2.704***	1.740***
	(0.010)	(0.077)	(0.008)	(0.093)	(0.020)	(0.195)
Controls	No	Yes	No	Yes	No	Yes
Village FE	No	Yes	No	Yes	No	Yes
N	16592	16546	15053	15020	15768	15729
R^2	0.043	0.512	0.006	0.320	0.014	0.376

Note: Model (2) includes village fixed effects and controls for age, education, education level for family members, exposure to TV and radio, variables for households wealth status and house condition, religion, variables for community culture and spouse family backgrounds. Standard errors, clustered in village level, are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

and 8.2 percent respectively. No effect is found on HIV/AIDS awareness, son preference, the probability to have a bank account and discussion of expenditure and politics.

Mobile phone service installation improved freedom of movement but the impacts are not significant. On the contrary, it had a more promising effect on increasing individual's involvement in decision making except for cooking. However, mobile phone service installation only increased the probability for individuals to have the most say in deciding what to do when a child is sick. The effects on decision-making involvement are large compared to the

Table 6: OLS results for fertility choice, financial independence and political awareness

	(1)	(2)	(1)	(2)	(1)	(2)
	Son preference		Have a bank account		Have cash in hand	
own_MP	-0.107***	-0.003	0.161***	0.036***	0.020***	0.010*
	(0.013)	(0.015)	(0.011)	(0.011)	(0.005)	(0.006)
age		0.006		0.030***		0.010***
		(0.006)		(0.004)		(0.002)
education_year		-0.008***		0.016***		0.003***
		(0.003)		(0.002)		(0.001)
_cons	0.327***	0.123	0.334***	-0.466***	0.924***	0.653***
	(0.010)	(0.146)	(0.008)	(0.094)	(0.004)	(0.061)
Controls	No	Yes	No	Yes	No	Yes
Village FE	No	Yes	No	Yes	No	Yes
N	14727	14689	16520	16473	16583	16536
R^2	0.006	0.221	0.025	0.301	0.001	0.228
	(1)	(2)	(1)	(2)	(1)	(2)
	Work participation		Expenditure discussion		Politics Discussion	
own_MP	-0.034***	0.012	0.023	-0.003	0.063***	0.011
	(0.011)	(0.009)	(0.015)	(0.015)	(0.018)	(0.016)
age		0.032***		0.016***		0.013**
		(0.004)		(0.005)		(0.005)
education_year		-0.004***		0.009***		0.011***
		(0.002)		(0.002)		(0.003)
_cons	0.705***	0.190**	1.442***	0.787***	0.899***	0.241*
	(0.009)	(0.089)	(0.012)	(0.132)	(0.014)	(0.136)
Controls	No	Yes	No	Yes	No	Yes
Village FE	No	Yes	No	Yes	No	Yes
N	16532	16485	15947	15906	15944	15903
R^2	0.001	0.405	0.000	0.391	0.002	0.397

Note: Model (2) includes village fixed effects and controls for age, education, education level for family members, exposure to TV and radio, variables for households wealth status and house condition, religion, variables for community culture and spouse family backgrounds. Standard errors, clustered in village level, are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: OLS results for freedom of movement

	(1)	(2)	(1)	(2)	(1)	(2)
	Health centre alone		Kirana shop alone		Friend's home alone	
own_MP	0.079***	0.030***	0.012	0.006	0.028***	0.011
	(0.010)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
age		0.027***		0.015***		0.018***
		(0.004)		(0.003)		(0.003)
education_year		0.010***		0.003**		0.007***
		(0.002)		(0.001)		(0.001)
_cons	0.696***	0.240***	0.815***	0.612***	0.794***	0.498***
	(0.008)	(0.090)	(0.006)	(0.079)	(0.007)	(0.081)
Controls	No	Yes	No	Yes	No	Yes
Village FE	No	Yes	No	Yes	No	Yes
N	16443	16396	15747	15703	16410	16363
R^2	0.007	0.295	0.000	0.296	0.001	0.328
	(1)	(2)	(1)	(2)	(1)	(2)
	Health centre permission		Kirana shop permission		Friend's home permission	
own_MP	-0.057***	-0.030***	-0.014	-0.008	-0.036***	-0.009
	(0.010)	(0.009)	(0.013)	(0.012)	(0.012)	(0.010)
age		-0.005*		-0.008*		-0.008***
		(0.003)		(0.004)		(0.003)
education_year		-0.000		0.001		-0.000
		(0.001)		(0.002)		(0.002)
_cons	0.804***	0.687***	0.571***	0.508***	0.701***	0.623***
	(0.007)	(0.077)	(0.010)	(0.102)	(0.009)	(0.081)
Controls	No	Yes	No	Yes	No	Yes
Village FE	No	Yes	No	Yes	No	Yes
N	16450	16403	13910	13869	16520	16473
R^2	0.004	0.392	0.000	0.389	0.001	0.421

Note: Model (2) includes village fixed effects and controls for age, education, education level for family members, exposure to TV and radio, variables for households wealth status and house condition, religion, variables for community culture and spouse family backgrounds. Standard errors, clustered in village level, are in parentheses.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: OLS results for having a say in decision-making process

| | (1) | (2) | (1) | (2) | (1) | (2) |
	Cooking		Large item purchase		No. of children	
own_MP	-0.003	0.008	0.010	0.011	0.023***	0.017***
	(0.004)	(0.005)	(0.009)	(0.009)	(0.006)	(0.006)
age		0.008***		0.018***		0.005**
		(0.002)		(0.003)		(0.002)
education_year		0.003***		0.005***		0.002**
		(0.001)		(0.001)		(0.001)
_cons	0.952***	0.823***	0.802***	0.505***	0.916***	0.860***
	(0.003)	(0.048)	(0.008)	(0.079)	(0.005)	(0.056)
Controls	No	Yes	No	Yes	No	Yes
Village FE	No	Yes	No	Yes	No	Yes
N	16579	16532	16468	16422	15801	15762
R^2	0.000	0.246	0.000	0.369	0.002	0.337
	(1)	(2)	(1)	(2)		
	Child sick		Child Marriage			
own_MP	0.020***	0.017***	0.022***	0.021***		
	(0.006)	(0.006)	(0.007)	(0.007)		
age		0.009***		0.008***		
		(0.002)		(0.003)		
education_year		0.002**		0.001		
		(0.001)		(0.001)		
_cons	0.907***	0.794***	0.884***	0.755***		
	(0.006)	(0.056)	(0.006)	(0.063)		
Controls	No	Yes	No	Yes		
Village FE	No	Yes	No	Yes		
N	16283	16241	16200	16158		
R^2	0.001	0.337	0.001	0.370		

Note: Model (2) includes village fixed effects and controls for age, education, education level for family members, exposure to TV and radio, variables for households wealth status and house condition, religion, variables for community culture and spouse family backgrounds. Standard errors, clustered in village level, are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: OLS results for having the most say in decision-making process

	(1)	(2)	(1)	(2)	(1)	(2)
	Cooking		Large item purchase		No. of children	
own_MP	0.001	0.021**	0.008	0.018***	0.036***	0.019*
	(0.010)	(0.010)	(0.006)	(0.006)	(0.010)	(0.010)
age		0.019***		0.007***		0.004
		(0.003)		(0.003)		(0.004)
education_year		0.005***		0.004***		0.004**
		(0.002)		(0.001)		(0.002)
_cons	0.743***	0.456***	0.120***	0.135**	0.241***	0.245***
	(0.007)	(0.086)	(0.004)	(0.068)	(0.007)	(0.090)
Controls	No	Yes	No	Yes	No	Yes
Village FE	No	Yes	No	Yes	No	Yes
N	16539	16492	16441	16395	15769	15731
R^2	0.000	0.327	0.000	0.396	0.002	0.309

	(1)	(2)	(1)	(2)	
	Child sick		Child marriage		
own_MP	0.055***	0.034***	0.016**	0.005	
	(0.010)	(0.010)	(0.008)	(0.007)	
age		0.008**		0.002	
		(0.004)		(0.003)	
education_year		0.002		0.002	
		(0.002)		(0.001)	
_cons	0.287***	0.412***	0.143***	0.265***	
	(0.007)	(0.087)	(0.005)	(0.068)	
Controls	No	Yes	No	Yes	
Village FE	No	Yes	No	Yes	
N	16250	16208	16161	16119	
R^2	0.003	0.358	0.000	0.431	

Note: Model (2) includes village fixed effects and controls for age, education, education level for family members, exposure to TV and radio, variables for households wealth status and house condition, religion, variables for community culture and spouse family backgrounds. Standard errors, clustered in village level, are in parentheses.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

coefficients of mobile phone ownership. One of the reasons could be the positive spill-over effect of mobile phone usage, as Akter and Chindarkar (2020) found there is a positive diffusion of empowerment. When mobile phone owners are empowered to be more involved in decision-making process, their family members and friends could learn from them and have higher involvement in these decision-making processes. This makes the OLS estimates to be downward-biased.

When principal components were used, results for difference-in-difference are robust. The coefficient for Treat*Post is significantly positive for decision-making involvement component and negative for work participation component. Furthermore, when using principal component, the coefficient for the freedom to go out alone is now significantly positive. When looked separately, the coefficients are positive but not significant.

As the panel data only included two survey rounds, parallel trend in pre-treatment period cannot be tested. To increase the likelihood that treated and control villages have followed the same trend, propensity score matching was used to match villages by village characteristics. The impact of mobile phone service was then estimated again using the observations that were matched. The results are presented in Figure A2, which are consistent with previous results calculated on the whole sample.
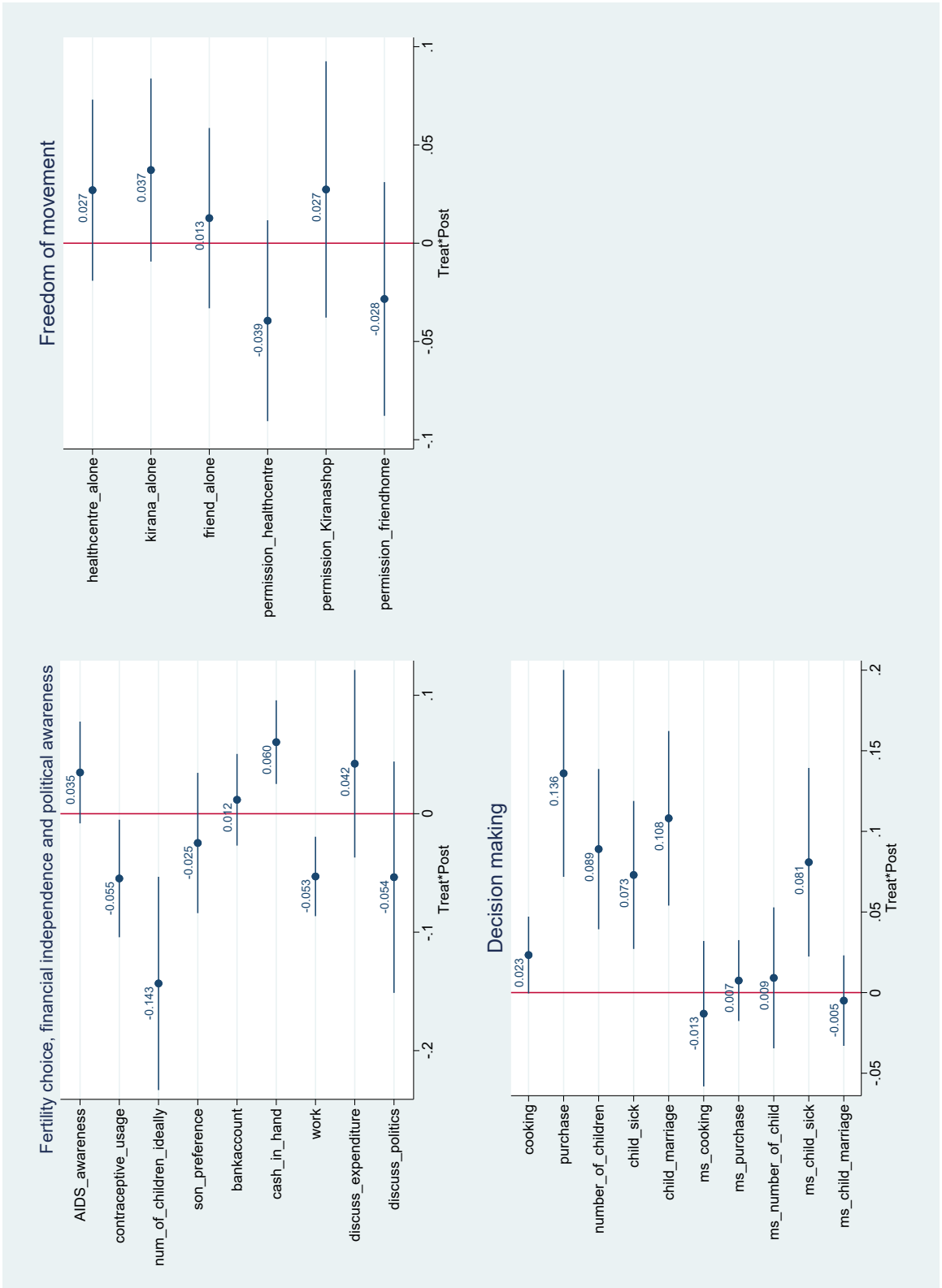
Figure 2: Coefficients for Treat*Post

7 Discussion and Conclusion

In this paper, Indian Human Development Surveys (IHDS and IHDS-II) were used to investigate quantitatively the impact of mobile phone ownership and mobile phone service installation on women's empowerment. The results suggest mobile phone ownership was associated with higher HIV/AIDS awareness, high financial independence in terms of having a bank account and cash in hand. It was also associated with higher involvement in decision making and higher chance to have the most say in the decision making process. The results of difference-in-difference strategy show that mobile phone service installation led to a higher involvement in the decision-making process, and lower work participation and contraceptive usage.

Although difference-in-difference strategy mitigates the reverse causality problem of OLS regressions, it also relies on the parallel trend assumption. If the survey were done in a more regular fashion, such as every two years, then villages that do not get mobile phone service can be used as control group. Furthermore, effect dynamic can be estimated and used to see whether parallel trend is likely to hold. Also, although two-years window is given to control group to account for the lag effect of mobile phone service, the time may not be long enough for the effect to materialise fully, as technological progress makes more functions available on mobile phones, which empower. Therefore, the parallel trend assumption could be violated and the impact of mobile phone service is underestimated.

Furthermore, although village-level fixed effect is added, there may be other time variant factors correlating with both treatment allocation and women's empowerment. For example, the roll out of internet service is likely to happen at the same time of mobile phone service. Therefore, the coefficients may reflect the effect of using internet on computers rather than mobile phone service. If effect dynamic suggests treatment effects occurs before mobile phone installation, then it could mean that higher women's empowerment is actually due to other policies or events.

In spite of these limitations, It seems plausible to say that mobile phones do empower women in some aspects. Results in this paper reflect mainly the impacts of mobile phones from the function of making calls, as few respondents in the sample used mobile phones for internet or SMS. Further research can be conducted to study the impacts of other mobile phone's functions to gain a comprehensive understanding of mobile phone's impact on women's empowerment. As technologies progress over time, continuous researches are required to keep updating the impacts of mobile phones to inform policymakers the ways to make use of these changes to empower women.

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