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Does the Internet Reduce Gender Gaps?

The Case of Jordan

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Abstract

This article investigates the link between digital technologies and female labor market outcomes in a country with one of the largest gender disparities. It exploits the massive roll-out of mobile broadband technology in Jordan between 2010 and 2016 to identify the effect of internet adoption on labor force participation. Using panel data at the individual level with rich information on labor market outcomes, internet use and gender-biased social norms, the article finds that internet adoption increases female labor force participation but has no effect on male labor force participation. The increase in online job search explains some—but not all—of the total increase in female labor force participation. Only older and skilled women experience an increase in employment in response to having internet access. The internet also reduces the prevalence of gender-biased social norms, early marriage and fertility.

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Does the Internet Reduce Gender Gaps? The Case of Jordan*

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1 Introduction

Women in the Middle East and North Africa (MENA) exhibit one of the lowest levels of labor force participation in the world (ILO (2017)). On average, only 20 percent of working age women in the region are either working or looking for a job, which is less than half of the levels observed in developing countries, such as those from Latin America, and Europe and Central Asia.[1]

There is a large body of literature exploring the drivers of this phenomenon. Typical hypotheses include the role of social norms regarding gender roles, legal differences by gender, the lack of childcare options as well as other factors (see, for example, World Bank (2018*b*), Bursztyn et al. (2018), Esfahani et al. (2015) and Assaad et al. (2014)). Yet, despite the substantial progress achieved in reducing gender gaps in other dimensions—such as educational attainment—the labor market outcomes of women have remained stagnant for decades in MENA.

In this article, we examine the impacts of digital technologies on labor market outcomes of women in Jordan. In particular, we estimate the impacts of increasing internet access on the probability of looking for a job as well as finding one. To our knowledge, the literature on the effects of digital technologies on female labor market outcomes is scarce and focused on countries where labor market segmentation across genders is less pronounced than in MENA (see, for example, Dettling (2017)).

Our main hypothesis is that increased internet access would have a positive effect on the labor market participation of women, especially in MENA countries, due to several factors. First, it lowers barriers to information about labor market opportunities, particularly for women who face mobility restrictions as in some of the countries in the region, where women are still legally required to ask permission to their husbands to travel outside the home (World Bank (2018*b*)). Second, it could provide more flexible forms of employment –such

[1] World Development Indicators, https://data.worldbank.org/indicator/SL.TLF.CACT.FE.ZS?locations=ZQ-1W-ZJ-7E, accessed on November 7, 2018.

as telecommuting– for women who could not otherwise work outside the home given their strong traditional roles as the main household caregivers. Third, the internet, as other communication technologies, may improve access to more information and thereby contribute to change social norms directly (Arias (2018)), and shift the bargaining power inside the household.

Using an instrumental variable for internet adoption, we find a large and statistically significant effect of having internet access on labor force participation among women. For every percentage point increase in internet access, women's labor force participation increases by 0.7 percentage points, while there are no significant effects on men's. The rise in online job search explains some–but not most–of the total increase in labor market activity among women. The internet does not improve employment outcomes, on average, among them. However, skilled and older women experience an increase in employment. Finally, the reduction in gender gaps in the labor market are accompanied by weakening gender-biased social norms as well as early marriage and fertility rates.

We use an instrumental variable approach since the link between individuals' internet adoption and labor market outcomes may be driven by omitted variables. Our instrument is the interaction between the distance to the nearest 3G tower and a proxy for pre-roll-out cost of internet access. Intuitively, an increase in internet coverage may have a greater effect on adoption in areas where communication costs were initially higher. We argue that this instrument satisfies the exclusion restriction since areas closer to the towers experienced similar pre-treatment trends in labor market outcomes than areas farther away. The findings are robust when evaluating alternative hypotheses—such as increasing access to other digital technologies—and when controlling for pre-treatment differences across localities and different specifications of the instrument. Moreover, unlike existing studies, the longitudinal structure of the data allows us to control for time-invariant unobserved factors at the individual level that may affect the link between internet adoption and labor market outcomes.

This study focuses on Jordan for several reasons. First, Jordan has a very low level

of female labor force participation, even when compared to other countries in the Middle East. Second, despite dramatic improvements in women's human capital over recent decades, their labor market outcomes have been rather stagnant (Winkler & Gonzalez (2019)). Third, internet use increased dramatically during the period under analysis (from 2010 to 2016), with the share of users increasing from 5 to 61 percent of the population. The increase was even larger for mobile broadband access, going from near zero in 2010 to approximately 60 percent of the population in 2016 (Telegeography (2018)). Such large increase, together with the availability of longitudinal data, is crucial to the design of the identification strategy of this article.

This article is structured as follows. Section 2 provides a review of the literature on the impacts of information and communication technologies (ICT) on labor market outcomes, with a focus on women in developing countries. Section 3 describes the data sources and main trends in labor market indicators and internet penetration, and section 4 discusses the identification strategy. Section 5 presents the results, and section 6 concludes.

2 Digital technologies and women's labor outcomes

This article contributes to the literature on the labor market impacts of internet access. The internet can affect labor market outcomes through different channels. It could contribute to improve labor market efficiency, by increasing access to information about job vacancies, lowering the recruiting costs for employers and increasing the quality of job matching (Autor (2000)). On the other hand, since this technology increases the economies of scale of job applications for potential workers, it could also increase the screening costs of firms significantly and lower matching quality (Oyer & Schaefer (2011)).

Empirical literature finds, in general, positive impacts of internet access on labor market outcomes. In the United States, unemployed individuals who search for a job online found a job 25 percent faster than those who search offline, even after accounting for other differences

between both groups (Kuhn & Mansour (2014)). Bagues & Sylos Labini (2007) find that the implementation of a job board by Italian universities reduced unemployment by 1.6 percentage points and increased wages by 3 percentage points for users. Kolko (2012) find positive impacts of broadband roll-out on population and employment growth at the zip-code level in the United States, with no impacts on the employment rate. None of these papers, however, analyzes the impacts by gender.

There is a growing empirical literature supporting the hypothesis that internet access has positive and larger impacts on women than on men. Klonner & Nolen (2010) find that increased mobile coverage in South Africa increased wage employment, particularly among women without child care responsibilities. Dettling (2017) finds that high-speed internet use in the United States increased labor force participation for married women with children, and had no impacts on single women and men. None of these papers, however, uses longitudinal data and thereby they fail to control by unobserved heterogeneity at the individual level. At the same time, they cannot disentangle if the impacts were driven by the new entrants into the labor force or by incumbents changing their labor market status. This is important, because the policy implications would be different if the impacts are driven by compositional rather than by behavioral changes. Finally, existing empirical evidence is not focused on contexts with gender disparities as large as in Jordan.

The findings of this article contribute to the literature of the impacts of information on social norms regarding gender roles. Arias (2018) finds that a randomized broadcast of a program aimed at challenging traditional gender roles in Mexico increased rejection toward violence against women. Accordingly, Jensen & Oster (2009) find that the introduction of cable television in India is associated with significant reductions in the acceptability of violence against women, and with an increase in women's autonomy. Bursztyn et al. (2018) show that correcting beliefs of young married men in Saudi Arabia about what other similar men think regarding female labor force participation increases married men's willingness to let their wives join the labor force.

3 Data

The main dataset used in this report is the Jordan Labor Market Panel Survey (JLMPS). This is a longitudinal household survey that was conducted in 2010 and 2016. It contains a host of rich variables on labor market outcomes, gender attitudes and use of digital technologies.[2]

Given the large inflow of Syrian refugees experienced by Jordan during this period, the sample includes Jordanian nationals only, aged 15 or more in 2010 and up to 64 in 2016. We restrict the sample to non-forced displaced people who are non-permanently disabled. The sample includes 2,843 women who were present in the 2010 and 2016 waves of the survey, and 2,758 men.

In Table 1 we present descriptive statistics on labor market and technology access variables, and individual and household level characteristics that we use as controls in our econometric analysis. Female labor force participation is low in Jordan. Less than one-fifth of women in our sample were part of the labor force in 2010, and while the percentage increased by 2016, it barely surpassed a quarter of the sample. For the sample of men, the labor force participation rate was high both in 2010 and 2016, averaging 75 percent and 79 percent respectively.

Mobile phone ownership is almost universal and the percentage of women and men living in households that own a laptop increased over time from 10 percent to 28 percent. Access to internet at home more than doubled between 2010 and 2016, increasing from 16 percent to 35 percent.

Figure 1 shows the female labor force participation rate disaggregated by subdistricts. In 2010, 11 of the 84 subdistricts with available data had no women in the labor force. In 2016, the number fell to only 3 subdistricts. On the other end of the scale, in 2010 the female labor force participation rate was below 50 percent in all subdistricts, while in 2016 12 subdistricts had a rate above 50 percent.

[2]Please see Krafft & Assaad (2018) for more information on these data.

Figure 2 presents the share of households with internet access at the subdistrict level. The number of subdistricts with a rate of internet access below 10 percent declined from 57 to 15 between 2010 and 2016; the number of subdistricts with an internet access rate between 10 percent and 50 percent increased from 26 to 55, while those surpassing 50 percent grew from 2 to 15.

Men and women in our sample are of a similar age—approximately 30 years old in 2010—more than half of them were married in 2010 and the percentage increased in 2016. The level of education is low; more than 50 percent of women and men had a basic level of education in 2010, although there was an improvement over time with an important increase in the percentages of women and men with post-secondary education or more.

In our empirical analysis we use the location of 3G cell towers in 2018 and the per capita expenditure on communications in 2010 to construct an instrumental variable. Data on the location of 3G cell towers come from the OpenCellID Project. OpenCellID collects the GPS position of cell towers which is defined as the GPS position (latitude and longitude) where the radio signal of a GSM base station is received. When more than one signal was received, the OpenCellID database provides the average latitude and longitude. The database contains information on different cellular network technologies, such as 2G (or GSM) and 3G (or UMTS), and on the number of measures processed to obtain a particular data point, i.e., the location of a cell tower. Data on per capita expenditure on communications come from the Household Expenditure and Income Survey (HEIS) of 2010. Expenditure in communication captures postal services, telephone and telefax equipment, and telephone and telefax services, including internet connection services.

4 Identification strategy

We estimate a reduced-form specification for men and women separately where we relate the change in labor force participation at the individual level with an indicator variable of

internet adoption or continuation –variable taking the value one if the household where a woman or a man lives adopted or continued using internet between 2010 and 2016, and zero otherwise (equation (1)):

$$\Delta Y_i^g = \alpha + \beta^g Internet_i^g + \Gamma X_i^g + \varepsilon_i^g. \tag{1}$$

Y_i^g in equation (1) takes the value one if person i of gender g participates actively in the labor market and 0 otherwise, and ΔY_i^g is the change in labor force participation between 2010 and 2016; $Internet_i^g$ is an indicator variable for whether the household where person i lives adopted internet or continued having access to it between 2010 and 2016; the vector X includes individual and household level characteristics in 2010 to control for differential trends across age, education, marital status, household size, wealth, and urban-rural areas. The model includes governorate fixed effects.

Even though the use of first-differences controls for any unobserved time-invariant factors, the estimate of β may still be biased if there are unobservable factors that vary over time and that are correlated with $Internet_i^g$. To overcome this challenge, we use an instrumental variable strategy, where the interaction between the distance to cell towers and the per capita expenditure in communications is used as an instrument for internet use. The first stage equation is:

$$Internet_i^g = \theta + \phi Distance\ tower_s^g * Exp_r^g + \eta X_i^g + \xi_i^g. \tag{2}$$

$Distance\ tower_s^g$ in equation (2) is the logarithm of the distance to the nearest 3G cell tower in the subdistrict s where a person of gender g lives, and Exp_r^g is the per capita expenditure in communication services in 2010 in the governorate r where a person of gender g lives.

This is a valid instrument for several reasons. First, it is correlated with internet use since shorter distances to the towers are typically accompanied by better internet access (Klonner & Nolen (2010)), and because the roll-out of 3G towers is expected to lower access costs disproportionately and thereby increase adoption among subdistricts where internet

prices were initially higher –captured by a higher value of the per capita expenditure in communication services in 2010. Second, it satisfies the exclusion restriction, since the model is estimated in first-differences, which controls for any time-invariant factors (such as distance) correlated with labor market outcomes, and because we include governorate fixed effects which control for differential trends in labor outcomes across geographic units, e.g., those related to different trends in development level. Third, fixed broadband access is very limited and did not experience significant changes in Jordan (see percentage of DSL subscribers in Figure 3), thereby mobile wireless access captures basically all of the increase in broadband access during this period. Before the availability of mobile broadband, the best mobile service available in Jordan was 2G (or GSM), which only allowed to place voice calls and send/receive text and media messages.

Our distance variable is defined as the logarithm of the average distance from all the coordinates defining the location of a subdistrict to the nearest 3G cell tower as of 2018, where each distance is weighted by the number of measures processed to get a particular tower location data point. We expect the number and location of 3G towers in 2018 to be a good approximation to the towers available in 2016 as the technology that started to be implemented from 2016 onwards was 4G (or LTE). 3G, jointly with 4G, were the more widespread type of technology to access internet services in 2016.[3] Mobile wireless subscribers increased substantially from only 2 percent of the population in 2010 to 59 percent in 2016 (Figure 3). Most of this increase is explained by 3G subscribers, as 4G technology appeared in 2015 and subscription was still low by 2016. Thus, we consider the distance to 3G towers in 2016 as a measure of the technological roll-out over the period under analysis.

First stage estimates are presented in Table 2 for two different sets of control variables and show that a shorter distance to the nearest 3G tower increases the chances of internet adoption or continuation for a given per capita expenditure in communications in 2010. For each 10% reduction in the average distance measure, the chances of adopting internet or

[3]Between 2010 and 2016, subscribers to fixed broadband internet (DSL technology) in Jordan kept around 3 percent of the population.

continuing having access to it increase by about 0.5 (column 1) and 0.4 percentage points (column 2) for both women and men in a governorate with average per capita expenditure in communications in 2010 (235 JOD in 2010 prices). In all cases, the F statistic surpasses 10, the rule for rejection of the hypothesis of weak instruments with one endogenous variable.

The assumption of similar pre-treatment trends is crucial for our identification strategy. We provide additional evidence on the validity of distance to 3G broadband towers as an instrument in Figure 4 and Table 3. We use data from the Jordan Population and Family Health Survey (JPFHS) 2002, 2007 and 2009 which provide us with information on employment previous to the deployment of 3G technology in the country. We calculate the average employment rate of women aged 15-49 in each subdistrict and we group them according to whether their distance to the nearest 3G cell tower in 2016 is above or below the average distance across subdistricts.[4] Figure 4 shows that the average women's employment rate followed the same trend in both groups of subdistricts. The same conclusion is obtained when estimating OLS models at the subdistrict level where the female employment rate is regressed on year dummies, an indicator for whether the distance to the nearest 3G tower in 2016 is below or equal to the average distance across subdistricts, and the interaction between these two variables. Results appear in Table 3 and show that the indicator of distance and the interaction terms are not statistically significant.

5 Effect of internet adoption on labor participation

Our main results are presented in Table 4. They show an increase in women's labor force participation associated with internet access under OLS and IV estimations, and no statistically significant effects for men. IV results indicate that a 1 percentage point increase in internet adoption or continuation between 2010 and 2016 led to an increase in female labor force participation of around 0.7 (column 5) and 0.8 (column 6) percentage points.

[4]The JPFHS interviews ever-married women age 15 to 49 and has information on employment but not on labor force participation. We were able to construct a balanced panel of 60 subdistricts for the period under analysis.

To better understand who were mostly impacted by internet adoption, we run models for different subgroups of women according to age, educational level and marital status in 2010. IV results using the most complete set of regressors appear in Table 5. The first stage F statistic is close to or above 10 in all models. When splitting the sample of women by age, we find that internet adoption or continuation between 2010 and 2016 impacted positively in labor force participation of both young (15-30) and adult women (31-58).[5] The analysis by educational level reveals a larger positive and statistically significant effect on labor participation of low-educated women (less than secondary education) in comparison to high-educated women (secondary education or more). Finally, when the analysis is performed by marital status, the results indicate a positive effect of internet adoption or continuation on labor participation of not married women (single, divorced or widow) and no effect on those who are married.

We also investigate whether other labor market indicators for women change as a result of internet access. We estimate model (1) using as dependent variable the overtime change in an indicator for job search using internet, and indicator variables for employment and unemployment. Results for the entire sample and for subgroups of women are presented in Table 6. Internet adoption led women to change their job search strategies as they started using the web to look for jobs (Panel A). This behavior appears for young women, low-educated and not married women and points to greater access to information as a channel to explain the increased labor force participation. The impacts are large in magnitude. A 1 percentage point increase in the probability of having internet access raises the incidence of online job search by about 0.3 percentage points. However, this increase is lower than the one observed in overall labor force participation (0.7 percentage points). In other words, an increase in the fraction of women reporting to have searched jobs online may explain some—but not all—of the overall increase in labor force participation as a result of increased internet access.

[5]We define adult women as 31-64 years of age. Because of the age restriction in our longitudinal sample (up to 64 in 2016), adult women were 31-58 in 2010.

However, on average, women were not successful in finding a job as the increase in labor force participation translated into increases in unemployment, with no statistically significant changes in the employment rate (Column 1 in Panels B and C). The only exception are older and skilled women who did, in fact, witness a significant increase in their employment probability. Women with high school education or more experienced an increase in their employment rate of about 0.49 percentage points for each one percentage point increase in the internet access rate. Nevertheless, given that the impact on labor force participation is higher than on employment, their unemployment rate rises. [6] The absence of significant average employment effects is in line with evidence showing limited job opportunities in the labor market of Jordan (Winkler & Gonzalez (2019)).[7]

5.1 Inspecting the mechanisms

5.1.1 Changes in social norms

In this section we investigate what drives the increase in labor force participation of women. One potential explanatory factor of the increase in female labor force participation as a result of internet adoption is the change in social norms regarding gender roles. The internet, as other communication technologies, may improve access to information contributing to change social norms directly (Arias (2018)), and to shift the bargaining power within the household.

We evaluate this mechanism using information from the JLMPS and constructing a wide array of variables capturing different dimensions of social norms including women's decision making power, women's access to money for home expenses, women's saving and ownership of valuables such as jewelry and land, violent behavior of husbands against their wives, women's being afraid of disagreeing with their husbands or other males in the households, and women's agreement with statements about women's empowerment.[8] We estimate model (1) using as

[6] We also run these models for the sample of men and the results show no statistically significant changes in job search using the internet, employment or unemployment.

[7] We do not analyze impacts on wage levels due to the very low number of women reporting wages in the sample.

[8] The decision-making power index is the average of indicator variables where 1 means women have

dependent variable the overtime change in the variables capturing different dimensions of social norms for the entire sample.

Results using the most complete set of control variables appear in Table 7. On the one hand, the decision making power index and the indicators for having access to home money and having savings or valuables do not change in response to increased internet access. These results are in line with the lack of impacts on female employment. Internet adoption helps women to enter the labor force but they are not successful in obtaining paid employment. This is consistent with the lack of impacts on indicators involving access to money, having savings or valuables, or participating in decisions where some of them involve home expenses. On the other hand, there is a decline in the probability of women approving of domestic violence or being afraid of disagreeing with their husbands or other males in the household. All these changes point to an increase in women's empowerment within the household and are consistent with their decision of participating in the labor market.

5.1.2 Changes in marriage and birth rates

We expect the increase in female labor force participation and the pattern of change in social norms to be connected with decisions about marriage and birth. Age at first marriage for women in Jordan is one of the lowest in the world, and marriage is highly linked to labor market exit (Winkler & Gonzalez 2019). Previous results pointed to some improvement in women's empowerment within the household which, jointly with the increase in women's labor force participation, could lead to a delay in decisions about marriage and birth. Previous literature on the impact of broadband internet on fertility decisions is not conclusive.

decision making power about daily needs, major household items, visiting family or friends, type of daily food, buying personal clothes, going to the doctor, taking children to the doctor, and buying clothes for children. The need of permit index is the average of indicator variables where 1 means woman needs permit to go to the market, go to the doctor, take children to the doctor, and visiting family or friends. The husband beats wife index is the average of indicator variables where 1 means husband justifies beating wife when she burns food, neglects child, argues with him, talk to other men, wastes money, and refuses sex. The opinion index is the average of indicator variables where 1 means woman agrees with the statement "women should work", "men should help wife with children", "men should help wife with chores", "girls go to school to prepare for jobs", "for financial autonomy women should work", "women should have leadership positions in society", "boys and girls should get same schooling", and "boys and girls should be treated equally".

Billari et al. (2019) find that broadband internet increased fertility in Germany and they linked this result to women's choice of telework and part-time work. We do not expect this channel to be at play in Jordan as internet adoption did not impact women's employment. Guldi & Herbst (2017), on the other hand, find that broadband diffusion helps to explain the decline in teen birth rate in the United States due to greater access to information.

We analyze the change in the marriage rate for women who were not married in 2010. IV results appear in Table 8. Column 1 shows the estimates for the sample of not married women in 2010, while columns 2 and 3 present the results when restricting the sample to low- and high-educated not married women in 2010. In both cases, we find that internet adoption or continuation between 2010 and 2016 reduces the marriage rate in about 0.6 and 0.9 percentage point for each one percentage point of increase in internet adoption. We next investigate whether internet adoption affected the birth rate by using as an outcome variable the number of 5-year-old or younger children in 2016 that each woman had. Results appear in columns 4 to 8 for the entire sample and for subgroups of women according to educational level and marital status. The estimates indicate a reduction in the number of children for the entire sample and for low-educated and not married of women of approximately 0.5 children over a 6-year period when moving from not having to having internet.

5.1.3 Comparative exercise

In order to further evaluate the importance of changing social norms as a mechanism to explain the increase in female labor force participation, we explore the impacts of internet adoption in a country where barriers for women are lower in comparison to Jordan. We explore the case of Chile where more than half of working age women have been participating in the labor market since 2000 (CEDLAS and The World Bank (2019)). This figure differs greatly from Jordan's statistics that showed that women's labor force participation was below 30% during 2010-2016 (Table 1).

We use individual longitudinal data from the Chilean Panel CASEN for the period 2006-

2009. Similar to the analysis performed for Jordan, we define the sample as women and men aged 15 or more in 2006 and up to 64 in 2009. The sample includes 4,261 women and 3,641 men who were present in both waves of the survey. We define an indicator of household internet adoption or continuation between 2006 and 2009 as the explanatory variable of interest and the change in labor force participation as the outcome variable. Table 9 shows that women's labor force participation increased from 49 to 52 percent between 2006 and 2009, while men's rate improved from 78 to 84 percent. Internet access at the household level moved from approximately 20 to 37 percent.

In Chile, the public fixed telephone network has been the most significant component of the internet access infrastructure at the beginning of the 2000s (Cominetti C. (2002)). Our hypothesis is that access to a fixed telephone line at that time is a good predictor of the distance to the system's backbone in future year, and thereby to internet access. We propose to use the share of households in each province that had a fixed telephone line in 2002 as an instrumental variable for the indicator of internet adoption or continuation between 2006 and 2009. We used information from the national 2002 Census which shows that this share ranged between 0.13 and 0.75.

We estimate OLS and IV models using individual and household observable characteristics in 2006 as control variables. We include the same set of regressors as in the previous models for Jordan –age, educational level, marital status, indicator of urban area, household size, and per capita household income. Models include region fixed effects and standard errors are clustered at the province level. Our main results appear in Table 10. Panel A presents the second stage estimates, while Panel B summarizes first stage results. The share of household that in each province had a fixed telephone line in 2002 is a good predictor of internet access or continuation between 2006 and 2009, and the F statistics of the first stage passes the usual threshold. Panel B shows an increase in women's labor force participation under OLS, but the effect disappears when we perform the IV estimation. For men, the effect of internet adoption or continuation is negative but not significant in any case. This

evidence points to changes in social norms regarding gender roles as a possible mechanism explaining the increase in women's labor force participation in Jordan.

5.2 Robustness

In this section, we present a set of robustness test to previous findings. First, we consider the possibility of our internet adoption or continuation variable to be capturing the impact of the adoption of other types of technologies, such as cell phones and computers. This type of technology devices may have an effect on the decision to participate in the labor market, for instance, through the accumulation of digital skills if the lack of abilities was one of the reasons for not being participating. We run previous models for the sample of women including as control variables the change in having a cell phone and having a computer. The results appear in Table 11 and show very similar estimates to previous ones both in terms of statistical significance and magnitude.

Second, our instrumental variable is based on the average distance from all the coordinates defining the location of a subdistrict to the nearest 3G tower. This strategy assumes that the same pattern of distance is replicated throughout the entire territory of a subdistrict. We relaxed this assumption by calculating the distance to the 10 nearest 3G towers and using it to construct the instrumental variable as the logarithm of the distance measure interacted with the per capita expenditure in communications in 2010. Figure 5 presents a comparison between the two measures. The average distance when using the 10 nearest 3G towers is 2.7 kilometers, while the average distance using the nearest tower is 1.8 kilometers. Estimates using the updated definition of the instrumental variable appear in Table 12 and confirm our previous findings.

Finally, we re-estimate previous models by including a vector of governorate-level controls reflecting local labor market characteristics and excluding the governorate fixed effects. These characteristics include female and male unemployment rates, shares of low-educated men and low-educated women in the labor force, and shares of young men and young women

in the labor force. Results are shown in Table 13 and confirm our previous finding.

6 Conclusion

This article provides new evidence on the impact of internet adoption on female labor force participation in a developing country. We use individual panel data for Jordan and link the change in labor force participation with a variable indicating internet adoption or continuation between 2010 and 2016. We use the interaction between the distance to 3G cellular towers and a proxy for internet prices as an instrument for internet adoption. We argue that this instrument satisfies the exclusion restriction since areas closer to the towers exhibited similar trends in female labor market outcomes before the roll-out of the 3G technology than areas farther away.

Our results provide new evidence that internet adoption has a positive effect on the labor force participation of women in developing countries. Since the impacts on men are not statistically significant, these findings imply that the internet contributes to reduce gender gaps in labor force participation. This is particularly important in the context of Jordan, where women's labor force participation is one of the lowest in the world. We also find that internet adoption leads women to change their job search strategy as they start using the web to look for jobs. However, this seems to explain only part of the overall increase in labor participation. Our findings indicate that the decline in gender gaps in labor force participation is accompanied by a reduction in gender-biased social norms, marriage and fertility.

On average, the internet does not have positive impacts on the likelihood of having a job. This, in combination with the large increase in activity, imply that unemployment rates of women increase on average and across groups. Only unmarried women and those with high school education or more experience an increase in employment.

Our findings suggest that the design of policies to promote the adoption of new technolo-

gies in developing countries with large gender gaps should consider the benefits associated with the greater inclusion of women in the labor market.

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Table 1
Descriptive Statistcs

	Women		Men	
	2010	2016	2010	2016
Labor market outcomes				
Labor force participation rate	18.49	26.66	74.52	78.98
Employment rate	14.53	17.58	67.89	71.03
Unemployment rate (as % of working age population)	3.97	9.08	6.63	7.95
Technology access				
=1 if hhld owns a mobile phone	0.98	0.99	0.99	0.99
=1 if hhld owns a laptop	0.10	0.28	0.10	0.28
=1 if hhld has internet access	0.16	0.35	0.16	0.34
Individual characteristics				
Age	30.66	37.48	30.32	37.15
=1 if married	0.57	0.76	0.50	0.74
=1 if basic education or less	0.52	0.43	0.58	0.50
=1 if secondary education	0.22	0.17	0.22	0.18
=1 if post-secondary education or more	0.26	0.40	0.20	0.32
Household characteristics				
Household size	6.13	5.14	6.24	5.29
Household wealth score	0.17	0.37	0.21	0.40
Observations	2,843		2,758	

Source: Own elaboration based on JLMPS.

Table 2
Household internet adoption and average distance to 3G cell towers

Dependent variable:	=1 if internet adoption or continuation			
	Women		Men	
	(1)	(2)	(1)	(2)
Log of distance to nearest 3G tower *	-0.000218	-0.000168	-0.000212	-0.000161
pc expenditure in communications in 2010	[0.0000]***	[0.0000]***	[0.0000]***	[0.0000]***
=1 if age [25,34]	-0.068	-0.0679	-0.104	-0.129
	[0.0219]***	[0.0236]**	[0.0384]**	[0.0407]***
=1 if age [35,44]	0.00233	-0.0247	-0.0608	-0.116
	[0.0156]	[0.0260]	[0.0282]*	[0.0293]***
=1 if age [45,54]	0.00256	-0.0463	0.0119	-0.05
	[0.0306]	[0.0434]	[0.0319]	[0.0397]
=1 if age [55,64]	-0.174	-0.177	0.0971	0.0181
	[0.0385]***	[0.0269]***	[0.119]	[0.114]
=1 if basic education or less	-0.147	-0.0679	-0.174	-0.128
	[0.0242]***	[0.0211]***	[0.0171]***	[0.0223]***
=1 if secondary education	-0.0703	-0.0323	-0.0219	-0.0122
	[0.0123]***	[0.0140]**	[0.0192]	[0.0194]
=1 if urban	-0.0236	-0.0477	-0.0112	-0.0276
	[0.0230]	[0.0256]*	[0.0345]	[0.0342]
=1 if married		0.049		0.0756
		[0.0287]		[0.0274]**
Household size		0.00704		-0.000475
		[0.00357]*		[0.00394]
Wealth score		0.117		0.0765
		[0.0176]***		[0.00653]***
Constant	0.502	0.433	0.71	0.659
	[0.0261]***	[0.0364]***	[0.0441]***	[0.0508]***
Observations	2,843	2,843	2,758	2,758
R-squared	0.075	0.115	0.077	0.094
F stat of excluded instruments	18.44	16.95	23.10	16.54

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.
Notes: All models control for governorates fixed effects. Omitted categories: 0-24 years of age; post-secondary education and more. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 3
Pre-treatment trends in women's employment rate

Dependent variable:	Female employment rate	
	(1)	(2)
=1 if 2002 * =1 if distance $\leq$ avg. distance	-0.00392	0.0123
	[0.0323]	[0.0317]
=1 if 2007 * =1 if distance $\leq$ avg. distance	0.00379	0.00247
	[0.0265]	[0.0235]
=1 if distance $\leq$ avg. distance	-0.012	-0.031
	[0.0277]	[0.0241]
=1 if 2002	-0.0456	-0.0309
	[0.0266]	[0.0167]*
=1 if 2007	-0.0264	-0.0111
	[0.00908]**	[0.0119]
Observations	180	180
R-squared	0.077	0.586

Source: Own elaboration based on JLMPS, OpenCellID Project and JPFHS 2002, 2007 and 2009.
Notes: All models control for governorates fixed effects. Column 2 controls for average age, educational level, marital status, household size and wealth score at the subdistrict level. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 4
Change in labor force participation on internet adoption

Dependent variable: Change in LFP	OLS				IV			
	Women		Men		Women		Men	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
=1 if internet adoption or continuation	0.0752	0.0585	0.0502	0.0515	0.716	0.819	0.0999	0.0386
	[0.0290]***	[0.0288]**	[0.0352]	[0.0342]	[0.132]***	[0.181]***	[0.237]	[0.238]
=1 if age [25,34]	-0.23	-0.223	-0.488	-0.432	-0.189	-0.172	-0.483	-0.433
	[0.0340]***	[0.0380]***	[0.0350]***	[0.0388]***	[0.0337]***	[0.0529]***	[0.0184]***	[0.0208]***
=1 if age [35,44]	-0.281	-0.284	-0.622	-0.512	-0.287	-0.268	-0.62	-0.513
	[0.0314]***	[0.0375]***	[0.0374]***	[0.0483]***	[0.0221]***	[0.0381]***	[0.0251]***	[0.0400]***
=1 if age [45,54]	-0.294	-0.305	-0.736	-0.609	-0.305	-0.276	-0.736	-0.609
	[0.0499]***	[0.0494]***	[0.0486]***	[0.0595]***	[0.0373]***	[0.0405]***	[0.0239]***	[0.0249]***
=1 if age [55,64]	-0.23	-0.226	-0.77	-0.645	-0.139	-0.108	-0.775	-0.645
	[0.0347]***	[0.0411]***	[0.100]***	[0.107]***	[0.0256]***	[0.0452]**	[0.141]***	[0.165]***
=1 if basic education or less	0.0211	0.0476	-0.0597	-0.0423	0.117	0.0974	-0.0507	-0.0439
	[0.0378]	[0.0387]	[0.0323]*	[0.0359]	[0.0373]***	[0.0385]**	[0.0446]	[0.0418]
=1 if secondary education	0.129	0.142	0.0714	0.082	0.175	0.166	0.0724	0.0819
	[0.0437]***	[0.0433]***	[0.0402]*	[0.0403]**	[0.0468]***	[0.0477]***	[0.0286]**	[0.0312]***
=1 if urban	-0.00734	-0.0182	0.0259	0.0237	-0.0105	0.00271	0.0249	0.0237
	[0.0233]	[0.0231]	[0.0235]	[0.0234]	[0.0289]	[0.0264]	[0.0205]	[0.0195]
=1 if married		0.00727		-0.129		-0.0329		-0.129
		[0.0326]		[0.0364]***		[0.0331]		[0.0247]***
Household size		0.0042		-0.00987		-0.000915		-0.0099
		[0.00586]		[0.00540]*		[0.00602]		[0.00452]**
Wealth score		0.044		7.29E-05		-0.0493		0.00115
		[0.0149]***		[0.0191]		[0.0254]*		[0.0142]
Constant	0.193	0.171	0.355	0.426	-0.102	-0.133	0.41	0.498
	[0.117]*	[0.121]	[0.0638]***	[0.0745]***	[0.0671]	[0.0871]	[0.132]***	[0.120]***
Observations	2,843	2,843	2,758	2,758	2,843	2,843	2,758	2,758
R-squared	0.109	0.114	0.282	0.287				

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.
Notes: All models control for governorates fixed effects. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Omitted categories: 0-24 years of age; post-secondary education and more. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 5
Change in female labor force participation on internet adoption by demographic groups.
Sample of women

Dependent variable:	Change in LFP					
	By age		By education		By marital status	
	15-30	31-58	Low-educated	High-educated	Not married	Married
	(1)	(2)	(3)	(4)	(5)	(6)
=1 if internet adoption or continuation	0.831	0.707	0.996	0.676	1.051	0.324
	[0.161]***	[0.392]*	[0.507]**	[0.0990]***	[0.270]***	[0.288]
Observations	1,457	1,386	1,642	1,201	1,170	1,673
F stat of excluded instrument	15.76	8.31	25.63	16.16	9.18	12.04
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.
Notes: All models control for governorates fixed effects. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Individual characteristics in 2010 include indicators of age, educational level, and marital status. Household characteristics in 2010 include indicator of urban area, household size, and wealth score. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 6
Change in job search, employment and unemployment on internet adoption. Sample of women

	All	15-30	31-58	Low-educated	High-educated	Not married	Married
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Change in job search using the internet							
=1 if internet adoption or continuation	0.325	0.456	0.0682	0.639	0.169	0.633	0.056
	[0.0592]***	[0.0844]***	[0.0483]	[0.0907]***	[0.0910]*	[0.204]***	[0.0801]
Panel B: Change in employment							
=1 if internet adoption or continuation	0.302	0.121	0.651	-0.107	0.487	0.33	0.189
	[0.220]	[0.177]	[0.342]*	[0.495]	[0.136]***	[0.285]	[0.210]
Panel C: Change in unemployment							
=1 if internet adoption or continuation	0.518	0.71	0.056	1.104	0.189	0.721	0.136
	[0.102]***	[0.183]***	[0.0930]	[0.178]***	[0.0953]**	[0.348]**	[0.131]
Observations	2,843	1,457	1,386	1,642	1,201	1,170	1,673
F stat of excluded instruments	16.95	15.76	8.31	25.63	16.16	9.18	12.04
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.
Notes: All models control for governorates fixed effects. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Individual characteristics in 2010 include indicators of age, educational level, and marital status. Household characteristics in 2010 include indicator of urban area, household size, and wealth score. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 7
Change in social norms on internet adoption. Sample of women

Dependent variable: Change in social norms	Decision making power index	=1 if accesses home money	=1 if has saving or owns valuables	Need of permit index	Husband beats wife index	=1 if afraid of disagreeing	Opinion index
All women							
=1 if internet adoption or continuation	-0.0762	0.267	-0.18	-0.113	-0.800	-1.191	0.139
	[0.0941]	[0.217]	[0.182]	[0.204]	[0.354]**	[0.586]**	[0.133]
Observations	2,843	2,843	2,843	2,843	2,843	2,843	2,843
F stat of excluded instruments	16.95	16.95	16.95	16.95	16.95	16.95	16.95
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.

Notes: All models control for governorates fixed effects. Decision making power index is the average of indicator variables where one means women has decision making power about daily needs, major household items, visiting family or friends, type of daily food, buying personal clothes, going to the doctor, taking children to the doctor, and buying clothes for children. Need of permit index is the average of indicator variables where one means woman needs permit to go to the market, go to the doctor, take children to the doctor, and visiting family or friends. Husband beats wife index is the average of indicator variables where one means husband justifies beating wife when she burns food, neglects child, argues with him, talk to other men, wastes money, and refuses sex. Opinion index is the average of indicator variables where one means woman agrees with the statement "women should work", "men should help wife with children", "men should help wife with chores", "girls go to school to prepare for jobs", "for financial autonomy women should work", "women should have leadership positions in society", "boys and girls should get same schooling", and "boys and girls should be treated equally".. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Individual characteristics in 2010 include indicators of age, educational level, and marital status. Household characteristics in 2010 include indicator of urban area, household size, and wealth score. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 8
Change in marriage and birth rates on internet adoption. Sample of women

Dependent variable:	Change in marriage			Number of 5-year-old or younger kids in 2016				
	Not married (1)	Not married low-educated (2)	Not married high-educated (3)	All (4)	Low-educated (5)	High-educated (6)	Not married (7)	Married (8)
=1 if internet adoption or continuation	-0.675 [0.204]***	-0.941 [0.392]**	-0.662 [0.160]***	-0.529 [0.191]***	-0.619 [0.312]**	-0.29 [0.199]	-0.529 [0.304]*	-0.442 [0.402]
Observations	1,170	690	480	2,843	1,642	1,201	1,170	1,673
F stat of excluded instruments	9.18	8.03	10.17	16.95	25.63	16.16	9.18	12.04
Individual characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.
Notes: All models control for governorates fixed effects. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Individual characteristics in 2010 include indicators of age, educational level, and marital status. Household characteristics in 2010 include indicator of urban area, household size, and wealth score. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 9
Descriptive Statistics - Chile 2006-2009

	Women		Men	
	2006	2009	2006	2009
Labor market outcomes				
Labor force participation rate	49.14	51.57	77.51	84.28
Employment rate	44.82	47.82	73.06	78.70
Unemployment rate (as % of working age population)	4.32	3.76	4.45	5.58
Technology access				
=1 if hhld owns a mobile phone	0.68	0.85	0.69	0.84
=1 if hhld owns a laptop	0.33	0.51	0.37	0.51
=1 if hhld has internet access	0.19	0.37	0.22	0.37
Observations	4,261		3,641	

Source: Own elaboration based on Panel CASEN.

Table 10
Change in labor force participation on internet adoption in Chile

Dependent variable:	Change in LFP			
	OLS		IV	
	Women	Men	Women	Men
	(1)	(2)	(3)	(4)
Panel A: Second stage				
=1 if internet adoption or continuation	0.0373	-0.0236	0.056	-0.0627
	[0.0186]**	[0.0163]	[0.121]	[0.0896]
Individual characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
Observations	4,261	3,641	4,261	3,641
R-squared	0.036	0.114		
Panel B: First stage				
Share of hhlds with			0.556	0.458
fixed telephone line in 2002			[0.0846]***	[0.0733]***
Observations			4,261	3,641
R-squared			0.215	0.23
F stat of excluded instrument			43.14	38.95

Source: Own elaboration based on Panel CASEN and 2002 Chilean National Census.
Notes: All models control for region fixed effects. Individual characteristics in 2006 include indicators of age, educational level, and marital status. Household characteristics in 2006 include indicator of urban area, household size, and per capita income. Robust standard errors clustered at the province level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 11
Controlling for cell phone and computer adoption. Sample of women

Dependent variable:	Change in LFP		Change in job search using internet	Change in employment	Change in unemployment	Change in marriage	# of children up to 5 in 2016
	Women	Men					
=1 if internet adoption or continuation	0.833	0.0462	0.324	0.315	0.518	-0.668	-0.533
	[0.180]***	[0.227]	[0.0590]***	[0.220]	[0.103]***	[0.194]***	[0.195]***
Observations	2,843	2,758	2,843	2,843	2,843	1,170	2,843
F stat of excluded instruments	16.96	18.28	16.96	16.96	16.96	8.87	16.96

Dependent variable:	Decision making power index	=1 if accesses home money	=1 if has saving or owns valuables	Need of permit index	Husband beats wife index	=1 if afraid of disagreeing	Opinion index
=1 if internet adoption or continuation	-0.0815	0.262	-0.177	-0.114	-0.798	-1.179	0.139
	[0.0969]	[0.214]	[0.180]	[0.204]	[0.351]**	[0.589]**	[0.131]
Observations	2,843	2,843	2,843	2,843	2,843	2,843	2,843
F stat of excluded instruments	16.96	16.96	16.96	16.96	16.96	16.96	16.96

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.
Notes: All models control for governorates fixed effects. Decision making power index, Need of permit index, Husband beats wife index and Opinion index as defined in Section 5.1.1. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Individual characteristics in 2010 include indicators of age, educational level, and marital status. Household characteristics in 2010 include indicator of urban area, household size, and wealth score. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 12

Using the distance to 10 nearest 3G towers to construct the instrumental variable. Sample of women

Dependent variable:	Change in LFP		Change in job search using internet	Change in employment	Change in unemployment	Change in marriage	# of children up to 5 in 2016
	Women	Men					
=1 if internet adoption or continuation	0.761	0.34	0.343	0.217	0.544	-0.705	-0.531
	[0.180]***	[0.244]	[0.0610]***	[0.231]	[0.134]***	[0.323]**	[0.206]***
Observations	2,843	2,758	2,843	2,843	2,843	1,170	2,843
F stat of excluded instruments	12.04	13.15	12.04	12.04	12.04	5.46	12.04

Dependent variable:	Decision making power index	=1 if accesses home money	=1 if has saving or owns valuables	Need of permit index	Husband beats wife index	=1 if afraid of disagreeing	Opinion index
=1 if internet adoption or continuation	-0.0687	0.251	-0.209	-0.037	-0.923	-1.223	0.316
	[0.122]	[0.198]	[0.194]	[0.226]	[0.393]**	[0.619]**	[0.198]
Observations	2,843	2,843	2,843	2,843	2,843	2,843	2,843
F stat of excluded instruments	12.04	12.04	12.04	12.04	12.04	12.04	12.04

Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.

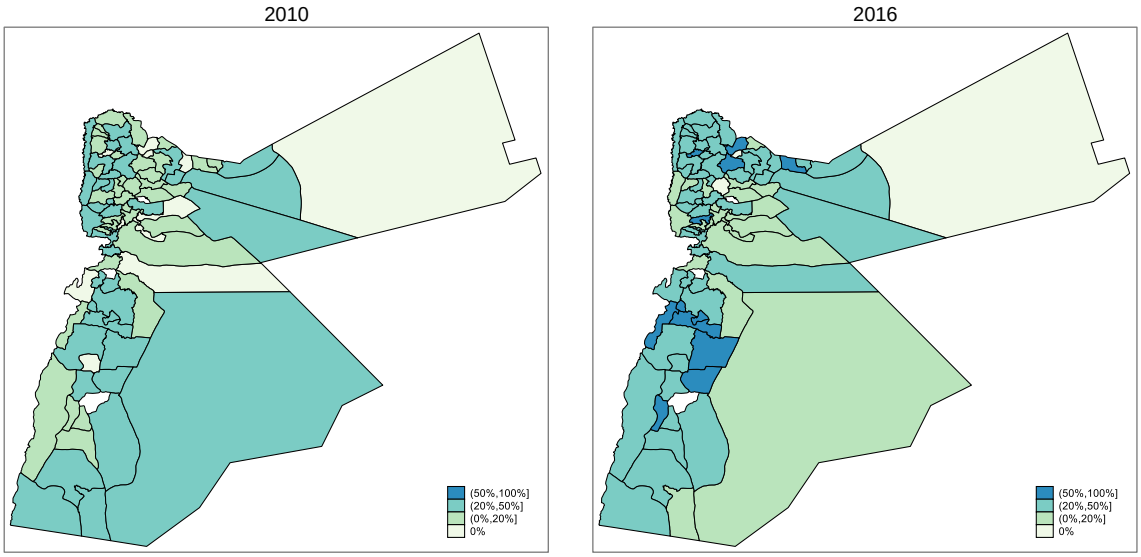
Notes: All models control for governorates fixed effects. Decision making power index, Need of permit index, Husband beats wife index and Opinion index as defined in Section 5.1.1. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Individual characteristics in 2010 include indicators of age, educational level, and marital status. Household characteristics in 2010 include indicator of urban area, household size, and wealth score. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 13
Controlling for local labor market characteristics in 2010. Sample of women

Dependent variable:	Change in LFP		Change in job search using internet	Change in employment	Change in unemployment	Change in marriage	# of children up to 5 in 2016
	Women	Men					
=1 if internet adoption or continuation	0.744	-0.245	0.32	0.27	0.474	-0.842	-0.971
	[0.148]***	[0.275]	[0.0672]***	[0.199]	[0.0977]***	[0.230]***	[0.462]**
Observations	2,843	2,758	2,843	2,843	2,843	1,170	2,843
F stat of excluded instruments	20.71	9.44	20.71	20.71	20.71	11.68	20.71
Dependent variable:	Decision making power index	=1 if accesses home money	=1 if has saving or owns valuables	Need of permit index	Husband beats wife index	=1 if afraid of disagreeing	Opinion index
=1 if internet adoption or continuation	-0.171	-0.043	-0.192	-0.0683	-0.504	-1.377	-0.136
	[0.156]	[0.272]	[0.148]	[0.184]	[0.477]	[0.509]***	[0.331]
Observations	2,843	2,843	2,843	2,843	2,843	2,843	2,843
F stat of excluded instruments	20.71	20.71	20.71	20.71	20.71	20.71	20.71

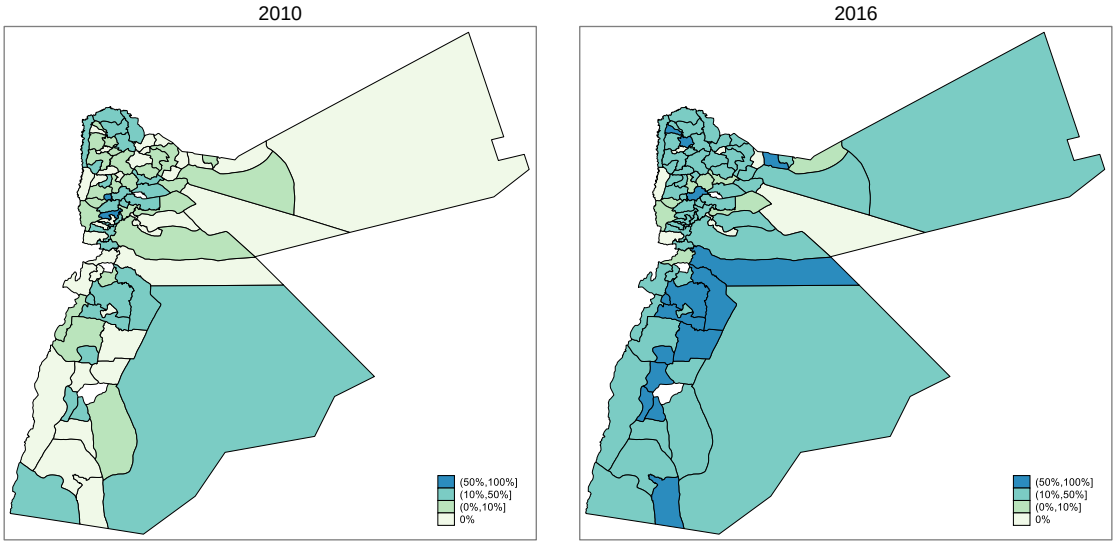
Source: Own elaboration based on JLMPS, OpenCellID Project and HEIS 2010.
Notes: All models control for governorates fixed effects. Decision making power index, Need of permit index, Husband beats wife index and Opinion index as defined in Section 5.1.1. The instrumental variable is the logarithm of the distance to the nearest 3G tower multiplied by the per capita expenditure in communications in 2010. Individual characteristics in 2010 include indicators of age, educational level, and marital status. Household characteristics in 2010 include indicator of urban area, household size, and wealth score. Robust standard errors clustered at the governorate level in brackets. *** p<0.01, ** p<0.05, * p<0.1

Figure 1
Women Labor Force Participation Rate by Subdistricts



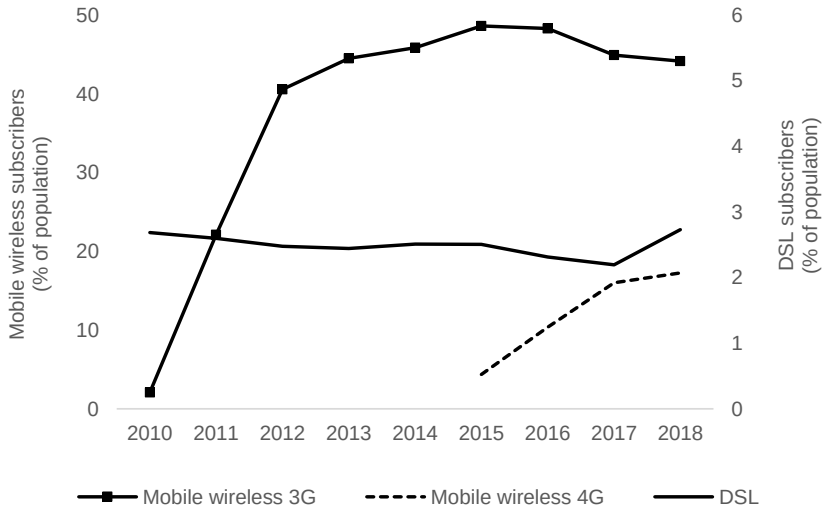
Source: Own elaboration based on JLMPS.

Figure 2
Internet Access by Subdistricts



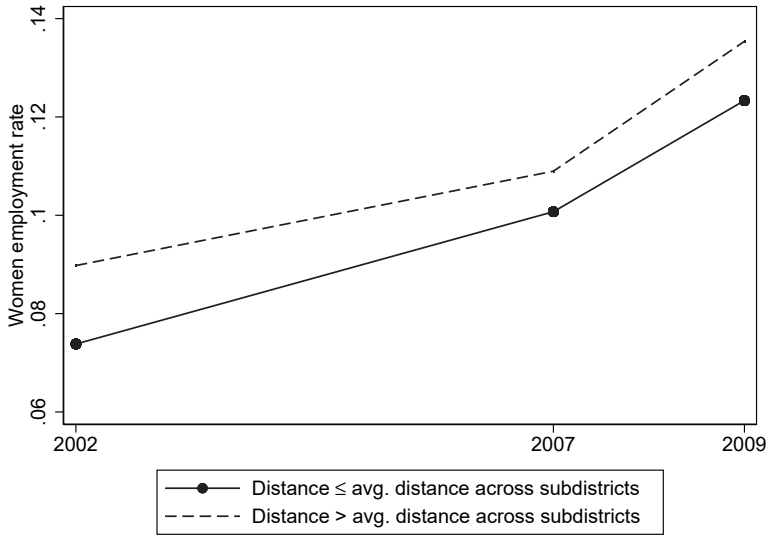
Source: Own elaboration based on JLMPS.

Figure 3
Broadband Internet Subscribers
as a Percentage of Total Population by Type of Technology



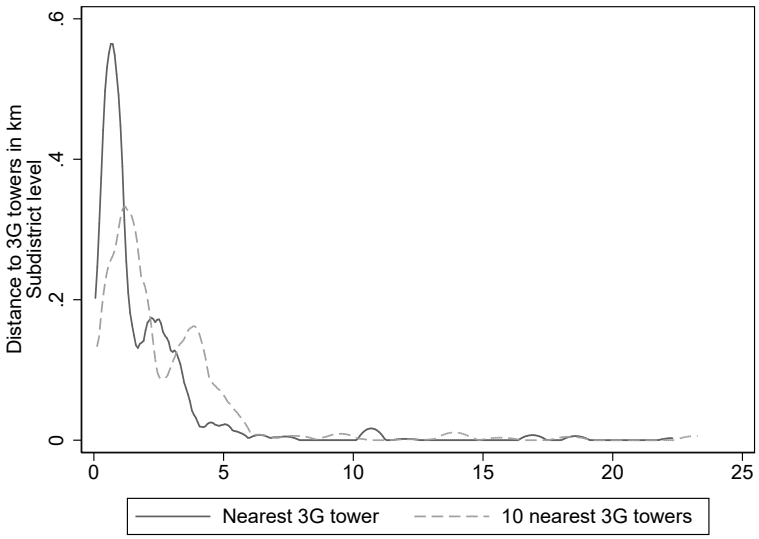
Source: Own elaboration based on Telegeography (2018) and World Bank (2018*a*).

Figure 4
Pre-treatment Trends



Source: Own elaboration based on JPFHS 2002, 2007 and 2009 and OpenCellID Project.

Figure 5
Comparison between distance measures to 3G cell towers



Source: Own elaboration based on JPFHS 2002, 2007 and 2009 and OpenCellID Project.