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Connecting alone: Smartphone use, quality of social interactions and well-being

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ABSTRACT

This paper investigates the role played by the smartphone for the quality of social interactions and subjective well-being. We argue that, due to its intrusiveness, the smartphone reduces the quality of face-to-face interactions and, as a consequence, their positive impact on well-being. We test this hypothesis in a large and representative sample of Italian individuals. The results indicate that time spent with friends is worth less, in terms of life satisfaction, for individuals who use the smartphone. This finding is robust to the use of instrumental variables estimation to deal with possible endogeneity. We also show that, consistent with our hypothesis, the positive association between time spent with friends and satisfaction with friends is less strong for individuals who use the smartphone.

1. Introduction

The advent of the smartphone has changed substantially the way we access information, allocate time and interact with others. These changes have important behavioral and social implications. In this paper, we focus on one of these implications: the effect of smartphone use on the quality of face-to-face social interactions. It is widely documented that the quantity and quality of social interactions play a key role for subjective well-being (e.g., Ateca-Amestoy, Aguilar, & Moro-Egido, 2014; Bruni & Stanca, 2008; Becchetti, Trovato, & Londono Bedoya, 2011).[1] We argue that the intrusiveness of the smartphone, arising from its portability and connectivity power, reduces the quality of face-to-face social interactions and, as a consequence, their value in terms of satisfaction and well-being.

The smartphone subsumes within a single device a wide range of technologies. It can simultaneously satisfy the need to make a phone call, take a photo, pay a bill, listen to music, watch a video, use the Internet, chat through social networks and,

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[1] See also the studies that value interpersonal relations by using implicit prices obtained by estimating subjective well-being equations (Clark & Oswald, 2002; Powdthavee, 2008; Stanca, 2009) or hedonic prices (Colombo & Stanca, 2014).

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more generally, be entertained. All these functions have substantially improved and simplified life. However, the very fact that these activities can be carried out anywhere, has made this technology more intrusive than any other.[2] While it can be claimed that the smartphone has simplified the way people maintain their interpersonal relationships (Cho, 2015) and fulfill their duties (Derks, Duin, Tims, & Bakker, 2015; Kossek & Lautsch, 2012), anecdotal evidence and experimental studies show that people often neglect those with whom they are physically interacting with, while preferring to indulge themselves in their smartphone and to connect to "online others" (Turkle, 2012).[3]

In the presence of the smartphone, even when in silent mode, the need of being constantly connected is strongly perceived. This state of *absent presence* (Katz & Aakhus, 2002) diverts attention from face-to-face social interactions. The resulting process of social fragmentation (Gergen, 2003) implies withdrawal from immediate relationships (Miller-Ott, Kelly, & Duran, 2012; McDaniel & Coyne, 2016). As a consequence, despite the existence of several smarthphone activities that involve interactions with others, overall the smartphone can be expected to play a negative moderating role on the relationship between face-to-face social interactions and subjective well-being.

We test this hypothesis empirically, using a large and representative sample of Italian individuals between 2010 and 2014, focusing on time spent with friends as an indicator of social interactions. We consider alternative empirical specifications to assess the robustness of the results, and instrumental variables estimation to deal with the possible endogeneity of both time spent with friends and smartphone use. Our findings indicate that time spent with friends is worth less, in terms of life satisfaction, for individuals who use the smartphone. In addition, we show that the positive association between time spent with friends and *satisfaction with friends* is significantly less strong for individuals who use the smartphone. Overall, the results are consistent with the hypothesis that the smartphone negatively affects the quality of face-to-face social interactions.

The paper is structured as follows. Section 2 briefly discusses the related literature. Sections 3 and 4 describe the data and methods, respectively. Section 5 presents the results. Section 6 concludes.

2. Related literature

Since the seminal work by Putnam (2000), the literature has devoted much attention to the role played by information and communication technologies for social interactions and social capital, with a special focus on television and the Internet (see, e.g., Bruni & Stanca, 2008; Frey, Benesch, & Stutzer, 2007; Gentzkow, 2006; Gentzkow, Shapiro, & Sinkinson, 2011; Jensen & Oster, 2009; Kearney & Levine, 2015; La Ferrara, Chong, & Duryea, 2012; Misra, Cheng, Genevie, & Yuan, 2016; Olkean, 2009; Pénard, Poussing, & Suire, 2013; Rosenblat & Mobius, 2004; Wellman, Haase, Witte, & Hampton, 2001). While some studies find a positive effect of communication technologies on social relations (e.g. Antoci, Sabatini, & Sodini, 2012; Bauernschuster, Falck, & Woessmann, 2014), and particularly among the elders (Lelkes, 2013), for whom social isolation can be particularly relevant, other studies show that the more time people spend using information technologies for virtual interactions, the less time they devote to other social activities and, in particular, to face-to-face social interactions (e.g. Olkean, 2009; Mumford & Winner, 2010).

Different technologies may have different effects on face-to-face social interactions, depending on their degree of intrusiveness. Gergen (2002) proposes a useful distinction between *monological* communication technologies, such as radio, cinema and television, and *dialogic* communication technologies, such as telephone, online social networks and the Internet. While monological technologies imply a uni-directional communication flow, without allowing any interactions, and are often used collectively (e.g., going to the cinema with friends), dialogic communication technologies imply an interactive communication flow and require instantaneous, although not necessarily physical, connection of the users.

The literature indicates that many aspects of everyday life can be affected by the use of the smartphone (e.g., Misra & Stokols, 2012; Mumford & Winner, 2010). Several studies have shown that the smartphone can affect individuals' relational life (e.g. Miller-Ott et al., 2012; McDaniel & Coyne, 2016; Sprecher, Hampton, Heinzel, & Felmlee, 2016), and that excessive use of the smartphone can lead to addiction (e.g. Mok et al., 2014) and reduced capacity to enjoy leisure (Janković, Nikolić, Vukonjanski, & Terek, 2016; Lepp, Li, Barkley, & Salehi-Esfahani, 2015). On the other hand, recent studies have shown that the smartphone has enabled employees to stay connected to work while being away from the office, and has increased flexibility and workers' ability to reconcile their work and non-work activities (Derks et al., 2015). Furthermore, smartphone-based interventions have been shown to enhance the effects of policies on a wide range of outcomes, from the adoption of positive health behaviors (Peck, Stanton, & Reynolds, 2014) to economic development (Aker & Mbiti, 2010) and educational activities (Shin, Shin, Choo, & Beom, 2011).

The main argument for the presence of negative spillover effects of the smartphone on well-being is that the continuous flow of information and communication created by the presence of a smartphone may alter sensory perception. Individuals are constantly exposed to a sensory overload (Misra & Stokols, 2012) that, combined with multitasking possibilities, leads to reduced concentration (Pea et al., 2012), learning (Poldrack & Foerde, 2008) and memorization abilities, with a resulting

[2] Estimates suggest that people spend on average up to five hours per day on their smartphone (Andrews, Ellis, Shaw, & Piwek, 2015), with the device being the first thing people look at in the morning and the last thing they look at before going to sleep.

[3] According to Deloitte Global Mobile Consumer Survey (Donato, 2015), based on a representative sample of Italian consumers, 74% of the respondents use their mobile phone while spending time with family or friends, 42% while attending a business meeting, and 31% while driving; 70% check their phones within 30 min after waking up in the morning and 63% check their phones within 30 min of preparing to sleep.

adverse effect in terms of well-being (Lee, Chang, Lin, & Cheng, 2014). Furthermore, the presence of a smartphone generates a *continuous* space where people can engage simultaneously in face-to-face and digital interactions without restrictions (Geser, 2004). This process hinders face-to-face interactions by diverting attention from immediate interpersonal experiences, while making other concerns more salient (Misra et al., 2016).

All these risks are difficult to recognize. Smartphones connect people with everyone, all the time and everywhere. This ubiquity witnesses to the development of a new social context where, although virtual connections are increasing, a sense of isolation may be widely perceived.

3. Data

Our empirical analysis is based on repeated cross-sectional data from the *Multipurpose Survey on Households: Aspects of Daily Life* (ISTAT, 2015), a large sample survey that covers the resident population in private households annually since 1993. Face-to-face interviews are carried out with Paper and Pencil Interview (PAPI) technique on a different sample of about 50,000 individuals (about 24,000 households) per year. The target population consists of all private households throughout the national territory. The selection of households is based on a two-stage sampling design, with municipalities as primary sampling units and households as secondary sampling units (Peracchi & Viviano, 2001). Municipalities are stratified by population size, with large municipalities being always included and smaller municipalities being selected randomly. The sampling frame is the centralized population register.

The data set contains detailed information on individual and household daily life, school, work, family and social life, spare time, political and social participation, health, life style, perceptions and time use, in addition to a wide range of individual-level and household-level characteristics. We consider five years, from 2010 to 2014, since life satisfaction, the main dependent variable in the analysis, is only available starting from 2010. The initial sample contains 207,658 individual observations (only 20,275 observations are available in 2013). We restrict the sample to individuals between 16 and 75 years of age. Since the survey is carried out on all family members, including children and elders, this restriction results in a sample of 148,088 observations overall (204,225 individuals for whom age is not missing, less 56,137 individuals below 16 or above 75 years of age). Table 1 reports descriptive statistics for all the variables used in the empirical analysis.

Subjective well-being is measured with life satisfaction, on a scale between 0 and 10, based on the question: "All things considered, how satisfied are you with your life as a whole these days?". Time spent with friends is measured from the following question: "How often in your free time do you meet with friends?", with 6 possible items: never, few times per year, less than four times per month, once a week, more than once a week, everyday. For ease of interpretation, we re-code this discrete variable into a dummy variable taking value 1 when respondents see their friends at least once a week, 0 otherwise (Time friends d1). In order to assess the robustness of the results, we also consider an alternative threshold with the resulting dummy variable being equal to 1 when respondents see their friends more than once a week, 0 otherwise (Time friends d2). Satisfaction with friends is a categorical variable based on the question: "How satisfied are you with your relations with friends?", with four possible outcomes (not at all satisfied, little satisfied, fairly satisfied, very much satisfied).

Smartphone use is measured by a dummy variable based on the question: "Do you use your mobile phone to surf the web?", where surfing the web means to make use of the mobile phone to connect to one of the following networks: GPRS, UMTS, 3G, 3G+, WI-FI. Smartphone penetration in Italy has grown steadily in the 5 years under investigation, rising from 7% in 2010 to almost 24% in 2014. Fig. 1, left panel, shows that there is substantial variability in smartphone penetration across regions, over the period 2010 to 2014, with a clear North–South digital divide. Sicily and Emilia Romagna display the lowest and highest smartphone penetration (9% and 17%, respectively). As for time spent with friends, the share of people declaring to see their friends at least once a week is more stable over time. However, as shown in Fig. 1, right panel, there is substantial variability across regions between 2010 and 2014, with a clear South-North relational divide. Lombardy and Basilicata display the lowest and highest fraction of people reporting to see their friends at least once a week (65% and 79%, respectively).

Additional individual characteristics include age, gender, employment status, marital status, parenthood status, educational level, and a self-assessed categorical measure of household economic conditions (insufficient, poor, adequate, excellent).

4. Methods

Our key hypothesis is that, ceteris paribus, the smartphone negatively affects the quality of face-to-face interactions, due to its high degree of intrusiveness, that often results in a state of absent presence. As a consequence, the positive relationship between time spent with friends on subjective well-being is expected to be less strong for those who use a smartphone. This hypothesis is tested by estimating the following specification:

$$SWB_{irt} = \beta_0 + \beta_1 F_{irt} + \beta_2 S_{irt} + \beta_3 F_{irt} S_{irt} + X_{irt}\Pi + \mu_r + \lambda_t + \varepsilon_{irt} \quad (1)$$

where *SWB* is the subjective well-being of individual i in region r in year t, measured by life satisfaction, F is time spent with friends, S denotes use of the smartphone, and X_{irt} indicates individual characteristics: age (a set of dummy variables for six age groups), gender (a dummy variable equal to 1 for males), employment (dummy variables for employed and unemployed status, respectively), marital status (a set of dummy variables for married, divorced and widowed), parenthood status (a

Table 1
Summary statistics. *Source*: Multipurpose survey on households (ISTAT, 2015).

Variable	Mean	Std. dev.	Min.	Max.	N
Life satisfaction	7.05	1.70	0	10	144,809
Satisfaction with friends	3.10	0.67	1	4	145,030
Smartphone use	0.13	0.34	0	1	144,830
Time spent with friends (d1)	0.70	0.46	0	1	147,125
Time spent with friends (d2)	0.47	0.50	0	1	147,125
Male	0.49	0.50	0	1	148,088
Age 16–24	0.12	0.33	0	1	148,088
Age 25–34	0.15	0.36	0	1	148,088
Age 35–44	0.19	0.39	0	1	148,088
Age 45–54	0.20	0.40	0	1	148,088
Age 55–64	0.19	0.39	0	1	148,088
Age 65+	0.15	0.36	0	1	148,088
Lower education	0.48	0.50	0	1	148,088
Medium education	0.39	0.49	0	1	148,088
Upper education	0.13	0.34	0	1	148,088
Employed	0.49	0.50	0	1	148,088
Unemployed	0.11	0.32	0	1	148,088
Married	0.56	0.50	0	1	148,088
Divorced	0.06	0.24	0	1	148,088
Widowed	0.04	0.20	0	1	148,088
Single	0.32	0.47	0	1	148,088
Parenthood status	0.49	0.50	0	1	148,088
Economic conditions: Insufficient	0.07	0.25	0	1	147,224
Economic conditions: Poor	0.38	0.48	0	1	147,224
Economic conditions: Adequate	0.54	0.50	0	1	147,224
Economic conditions: Excellent	0.01	0.10	0	1	147,224
2010	0.24	0.43	0	1	148,088
2011	0.23	0.42	0	1	148,088
2012	0.23	0.42	0	1	148,088
2013	0.08	0.26	0	1	148,088
2014	0.23	0.42	0	1	148,088
Smartphone penetration (region/year av.)	0.14	0.07	0.04	0.28	148,088
Time spent with friends (region/year av.)	0.70	0.04	0.61	0.80	148,088
Time spent at work (region/year av.)	20.40	3.24	14.94	29.02	148,088

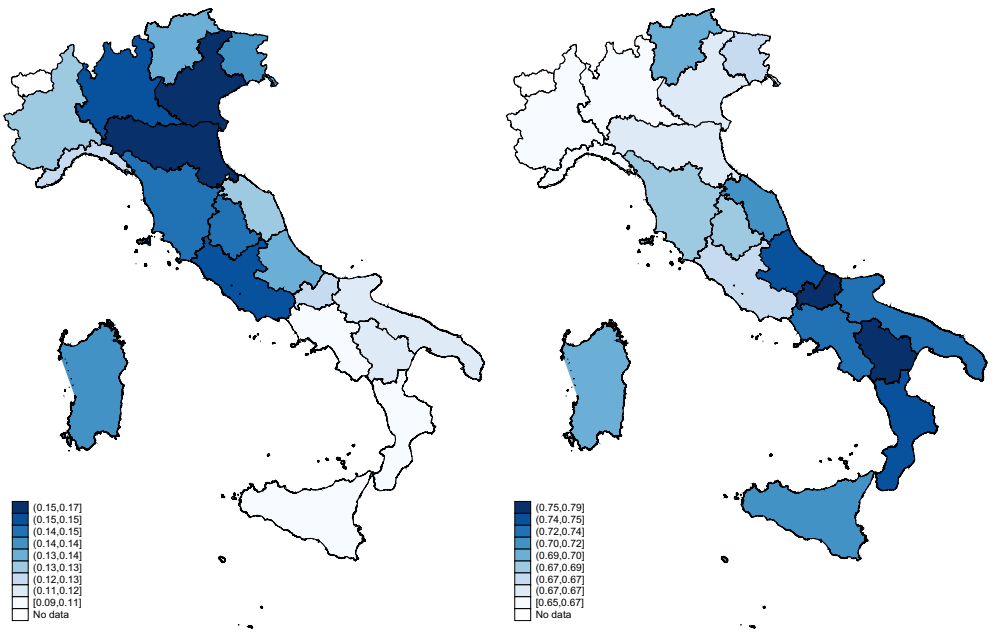

Fig. 1. Smartphone penetration and time spent with friends, by region.

dummy variable equal to 1 if the respondent has children), educational level (dummy variables for medium and upper education, respectively), and a set of dummy variables for self-assessed household economic conditions (insufficient, poor, adequate, excellent).

Time fixed effects (λ_t) are included to allow for heterogeneity across different survey waves. Region dummy variables (μ_r) are included to control for cultural and societal differences that might play a role in explaining spatial variability in well-being, so that unobserved heterogeneity due to regional-level environmental differences is controlled for. The coefficient β_3, the key parameter of interest, can be interpreted as the difference, between smartphone users and non-users, in the effect of time spent with friends on subjective well-being. For ease of interpretation, Eq. (1) is estimated by Ordinary Least Squares (OLS). Standard errors robust to heteroskedasticity are clustered at the household level in order to take into account the fact that, in each survey wave, we observe several individuals from the same household.[4]

An important methodological issue is the potential endogeneity of both our key explanatory variables (smartphone use and time spent with friends). There are several possible sources of endogeneity undermining the causal interpretation of the results. First, endogeneity may arise from unobserved heterogeneity at the individual level, as smartphone use, time spent with friends and well-being might be jointly determined by unobserved individual characteristics. It could be the case, for instance, that time spent with friends and smartphone use are simultaneously affected by unobserved personality traits, such as extraversion or self-esteem. Second, we cannot rule out reverse causality. It could be the case that happier individuals are more likely to use the smartphone or to see their friends more often. In order to address these issues, we make use of instrumental variables estimation (IV), considering both time spent with friends and smartphone use as potentially endogenous.

5. Results

We start by presenting estimation results for the baseline specification in Eq. (1), while assessing the robustness of the findings to the use of alternative indicators of social interactions and empirical specifications. Next, we examine the causal interpretation of the results, by addressing the potential endogeneity of both social interactions and smartphone use. Finally, in order to assess the interpretation of the results, we investigate the effects of smartphone use on the value of time spent with friends in terms of satisfaction with friends.

5.1. Smartphone, social interactions and well-being

Table 2 presents OLS estimation results for Eq. (1), based on a sample of about 140,000 individuals. All specifications include region and year fixed effects. Column (1) reports estimates obtained by measuring time spent with friends with a dummy variable taking value 1 when respondents see their friends at least once a week. Column (2) reports, as a robustness check, estimation results obtained by using an alternative definition of time spent with friends: a dummy variable equal to 1 when respondents see their friends more than once a week (column 2). Due to space limitations, Table 2 only reports estimated coefficients for a subset of the explanatory variables. Additional explanatory variables, not reported in the table, are described in Section 4.

We start by considering the results for the control variables, in order to provide a preliminary assessment of the empirical specification. Across individuals, being unemployed is negatively and significantly related to life satisfaction. Individuals who are married or have higher education levels report significantly higher levels of well-being. Males are less satisfied with their life, *ceteris paribus*, than females. These results, based on the overall sample, are qualitatively consistent with those generally found in the literature.

Time spent with friends is positively and significantly related to life satisfaction, consistent with the literature. Indeed, the estimated main effect is sizeable in relative terms (0.307 and 0.238, respectively, for the two definitions of the dummy variable). Smartphone use is positively and significantly related to life satisfaction, with an estimated coefficient of 0.127 and 0.163, respectively, in the two specifications, consistent with previous findings in the literature (Cho, 2015).[5] As predicted, the coefficient for the interaction term between smartphone use and time spent with friends is negative and strongly significant. This indicates that, ceteris paribus, smartphone use partially offsets the positive impact of time spent with friends on life satisfaction. The size of the interaction term, estimated at about 40% of the main effect for no-smartphone individuals, is also quantitatively relevant.

The negative interaction between smartphone use and time spent with friends is qualitatively and quantitatively robust to the use of an alternative indicator of time spent with friends. The coefficient for the interaction term is −0.090, and statistically significant, when time spent with friends is defined as a dummy variable equal to 1 when respondents see their friends more than once a week (column 2). The results are also qualitatively unchanged when cardinalising time spent with friends (e.g., never = 0, few times per year = 3, less than four times per month = 24, once a week = 52, more than once a week = 100, every day = 365).

[4] Given the large sample size of our data set, although in the presentation of the results we will consider significance levels of either 0.05 or 0.01, we will focus on the latter to assess statistical significance.

[5] The results in Table 2 indicate that having a smartphone is positively associated with well-being for those who see friends less frequently. It can also be shown that smartphone use is positively and significantly related to well-being for those who see their friends more frequently (0.163–0.112 = 0.051, $p < .01$).

Table 2
Smartphone use, social interactions and well-being (OLS).

	(1)	(2)
Time friends (d1)	0.307**	
	(0.012)	
Time friends (d1) × Smartphone	−0.112**	
	(0.031)	
Time friends (d2)		0.238**
		(0.011)
Time friends (d2) × Smartphone		−0.090**
		(0.025)
Smartphone use	0.163**	0.127**
	(0.029)	(0.020)
Male	−0.017*	−0.018*
	(0.008)	(0.008)
Upper education	0.160**	0.167**
	(0.015)	(0.015)
Medium education	0.062**	0.065**
	(0.011)	(0.011)
Unemployed	−0.461**	−0.457**
	(0.019)	(0.019)
Married	0.396**	0.404**
	(0.015)	(0.016)
R^2	0.121	0.119
N.	139,451	139,451

Note: dependent variable: Life Satisfaction. OLS estimates. Additional explanatory variables, not reported in the table, are described in Section 4. Heteroskedasticity-robust standard errors clustered at the household level reported in brackets (* $p < .05$, ** $p < .01$).

It is important to observe that, due to data limitations, the results presented in Table 2 are based on specifications that do not include a direct measure of income among the explanatory variables, but only self-assessed economic conditions and employment status. To the extent that these proxy variables may not adequately capture actual income, and that smartphone use is related to income level, the results presented above could be interpreted as indicating that individuals with higher income value social interactions relatively less in terms of well-being. In order to shed light on this alternative interpretation, Table 3 presents estimation results for a specification that also includes interactions of time spent with friends with self-assessed economic conditions. The coefficient for time spent with friends is indeed smaller for individuals with better self-assessed economic conditions. However, the coefficient for the interaction between time spent with friends and smartphone use is still negative (-0.088 and −0.076, respectively, for the two alternative definitions of the time friends dummy variable) and statistically significant. These findings indicate that smartphone use is not simply playing a role as a proxy for income.

5.2. Endogeneity

The results presented above provide evidence of a negative interaction between smartphone use and time spent with friends. Although we control for a large set of individual characteristics, we cannot rule out the possibility that the two key explanatory variables are endogenous. In order to assess the interpretation of our results, we turn to an instrumental variables (IV) estimator.

It is generally difficult to find appropriate instruments for choice variables at the individual level. We thus focus on aggregate (average) variables at the region/year level. More specifically, we use the variable "share of respondents in each region/year declaring to use the smartphone" (z_1) as an instrument for the use of the smartphone, under the assumption that people are more willing to own and use a smartphone if this technology is more widespread among their acquaintances. As for time spent with friends, we use as instruments the share of respondents in each region/year who see their friends at least once a week (z_2) and the average time (hours per week) spent at work in each region/year (z_3).[6] The rationale for the latter instrument is that the longer hours people work, the less time they can devote to social interactions.[7] We acknowledge that the exogeneity of this instrument could be questioned. For example, it could be the case that richer individuals live in richer regions where smartphones are more common and people enjoy higher (or lower) levels of social interactions. However, the estimated specification includes a self-assessed measure of household economic conditions.

[6] Note that all the instruments are at the regional level. Although the first-stage specification contains region fixed effects, capturing any time-invariant unobserved variables at the regional level, the region averages used as instruments vary across regions and over time.

[7] Time dedicated to work at the individual level can be expected to be correlated with social interactions. However, it cannot be used as an instrument, since it may directly affect well-being. We thus use the average number of hours worked per week, by year and region, under the assumption that a higher availability of free time at the regional level makes social interactions more likely at the individual level.

Table 3
Smartphone use, social interactions and well being: robustness.

	(1)	(2)
Time friends	0.722**	0.556**
	(0.054)	(0.049)
Time friends × Smartphone	−0.088**	−0.076**
	(0.031)	(0.025)
Smartphone use	0.144**	0.119**
	(0.029)	(0.020)
Economic cond.: Poor × Time friends	−0.360**	−0.271**
	(0.056)	(0.051)
Economic cond.: Adequate × Time friends	−0.515**	−0.390**
	(0.055)	(0.050)
Economic cond.: Excellent × Time friends	−0.477**	−0.395**
	(0.113)	(0.099)
R^2	0.122	0.120
N.	139,451	139,451

Note: dependent variable: Life Satisfaction. OLS estimates. Additional explanatory variables, not reported in the table, are described in Section 4. Heteroskedasticity-robust standard errors clustered at the household level reported in brackets (* $p < .05$, ** $p < .01$). Columns (1) and (2) are based on two alternative definitions of the dummy variable for time spent with friends, as in columns (1) and (2) of Table 2.

Table 4 reports IV estimation results. In order to assess the robustness of the results to the choice of the instruments, we consider three IV specifications. Columns (1) and (2) use as instruments z_1, z_2 and z_1, z_3, respectively, while column (3) uses z_1, z_2, and z_3. Since the interaction between smartphone use and time spent with friends can also be endogenous, the set of instruments also includes pair-wise interactions between z_1, z_2, and z_3, as detailed at the foot of each column in Table 4. This results in a set of three instruments in columns (1) and (2), and six instruments in column (3). Anderson-Rubin F-tests, reported at the bottom of Table 4, indicate that the instruments are jointly significant in the first-stage equations for each of the three potentially endogenous variables (smartphone use, time spent with friends, and their interaction). As shown in column (3), the validity of the three instruments is not rejected by a Sargan test of over-identifying restrictions (χ^2=4.94, $p = 0.176$).

The coefficient for the interaction between time spent with friends and smartphone use is negative and significant in all three specifications, similarly to the OLS results presented above. The fact that IV estimates for the key parameter of interest are much larger than OLS estimates reflects the lower variability of the instruments relative to the instrumented variables. Overall, IV estimation results are consistent with the hypothesis that the smartphone has a negative effect on the quality of social interactions.

5.3. Smartphone use and satisfaction with friends

Our proposed interpretation for the negative interaction between time spent with friends and smartphone use in Eq. (1) is that the smartphone reduces the quality of face-to-face interactions. In order to assess this interpretation, we focus on the moderating role played by the smartphone for the relationship between time spent with friends and *satisfaction with friends*. Table 5 reports OLS estimation results, based on the specification described in Eq. (1). Column (1) focuses on satisfaction with friends as a dependent variable. The interaction term between smartphone use and time spent with friends is, as above, negative and strongly significant.[8] This finding indicates that spending time with friends is less valuable, also in terms of *satisfaction with friends*, for those who use the smartphone, consistent with the hypothesis that the smartphone negatively affects the quality of social interactions.

In order to further assess the effect of smartphone use on relational quality, we construct an indicator of *net* relational satisfaction, defined as the difference between satisfaction with friends and satisfaction with leisure.[9] The rationale for using this alternative indicator is that the negative effect of smartphone use on the value of time spent with friends in terms of well-being could be attributed either to a pure fragmentation effect (Janković et al., 2016; Lepp et al., 2015) or, more specifically, to a specific adverse effect on the quality of face-to-face interactions. By taking the difference between satisfaction with friends and satisfaction with leisure we aim at disentangling the adverse relational effect of the smartphone, which includes the increasing overlap between work and family time (Derks et al., 2015; Derks, Bakker, Peters, & van Wingerden, 2016), from the more general fragmentation effect on time use (Lepp et al., 2015). The results, reported in column (2), indicate that the interaction

[8] Note that the size of the coefficients for life satisfaction and satisfaction with friends, reported in Tables 2 and 5, respectively, are not directly comparable, as the two dependent variables are defined on different scales.

[9] Satisfaction with friends and satisfaction with leisure are both measured on a four-item scale, with answers ranging from not satisfied at all (1) to very satisfied (4).

Table 4
Smartphone use, social interactions and well-being: IV estimates.

	(1) Life satisfaction	(2) Life satisfaction	(3) Life satisfaction
Time friends	0.094	1.053	0.133
	(0.405)	(1.839)	(0.419)
Smartphone	7.806**	8.960**	8.601**
	(2.648)	(2.959)	(2.604)
Time friends (d1) × Smartphone	−8.803**	−10.216**	−9.752**
	(3.218)	(3.583)	(3.150)
Instruments	z_1, z_2	z_1, z_3	z_1, z_2, z_3
Anderson-Rubin F-test	4.55	5.37	4.35
P-value	($p = 0.003$)	($p = 0.001$)	($p = 0.000$)
Hansen J statistic χ^2			4.945
P-value			($p = 0.176$)

Note: dependent variable: Life Satisfaction. IV estimates (2-stage least squares). Additional explanatory variables, not reported in the table, are described in Section 4. The set of instrumental variables also includes pair-wise interactions between the instruments, as reported at the foot of each column in the table. Heteroskedasticity-robust standard errors clustered at the household level reported in brackets (*p < .05, **p < .01).

Table 5
Smartphone use, social interactions and satisfaction with friends.

	(1) Satisfaction with friends	(2) Sat. difference
Time friends (d1)	0.375**	0.087**
	(0.005)	(0.006)
Smartphone use	0.087**	0.060**
	(0.012)	(0.016)
Time friends (d1) × Smartphone	−0.057**	−0.052**
	(0.013)	(0.017)
N.	139,677	139,446

Note: dependent variable and estimator as reported in column headings. Sat. difference = satisfaction with friends – satisfaction with leisure. OLS estimates. Additional explanatory variables, not reported in the table, are described in Section 4. Heteroskedasticity-robust standard errors clustered at the household level reported in brackets (*p < .05, **p < .01).

between time spent with friends and smartphone use is negative, statistically significant, and quantitatively relevant. This suggests that the effect of the smartphone on the quality of face-to-face interactions is negative and significant even when controlling for the fragmentation effect, providing further support to the hypothesis that the smartphone negatively affects the quality of face-to-face interactions.

As an additional assessment of the interpretation of the results, we experimented by using as a dependent variable satisfaction with life domains for which the effect of time spent with friends is not expected to differ for smartphone users. We thus estimated the model above by using, as a dependent variable, satisfaction with either the environment or economic conditions. Consistent with our predictions, the coefficient for the interaction between time spent with friends and smartphone use was not found to be statistically significant for either satisfaction with the environment (−0.008, $p = .620$) or satisfaction with economic conditions (−0.010, $p = .478$).

6. Concluding remarks

The smartphone has dramatically changed our daily life and, in particular, how we interact with others. These changes have made life easier in many respects. Yet, they did not come without costs. This paper attempted to shed light on one of these potential costs: the adverse effect of the smartphone on the quality of face-to-face social interactions. We argued that the intrusiveness of the smartphone, arising from its powerful connecting capabilities together with small size and portability, reduces the quality of face-to-face social interactions, thus dampening their positive impact on well-being.

We tested this hypothesis empirically in a large sample of Italian individuals. Our results suggest that the use of the smartphone negatively affects the quality of time spent with friends. This finding is robust to the use of alternative specifications and estimation techniques to deal with possible endogeneity. Consistent with our hypothesis, we find that the positive association between time spent with friends and *satisfaction with friends* is also less strong for individuals who use the smartphone. In addition, our findings indicate that the negative mediating role played by the smartphone for the relationship between time spent with friends and well-being can be attributed not only to a pure fragmentation effect, but also to a specific adverse effect on the *quality* of face-to-face interactions (Turkle, 2012). This is an important aspect of the transformation of social life brought about by mobile communication (Katz, 2006).

Our results have relevant policy implications. The smartphone is by far the world's most popular and intrusive electronic device. Its functions permeate daily life to such an extent that, according to the latest available Pew Research Center data, 46 per cent of smartphone owners say they could not live without their phone (Smith, McGeeney, Duggan, Rainie, & Keeter, 2015). Seminal technologies require people to adapt to them and smartphones are no exception. This process of adaptation, however, requires careful attention and a better understanding of the mechanisms through which such major changes occur in our daily life.

Smartphones can be empowering in many respects. They reduce the cost of information gathering, enable individuals to work from anywhere they wish, and can help spread relevant information that can favor disadvantaged groups. However, while the smartphone can bring distant people closer together, at least virtually, it can also make close people more distant. More generally, it can negatively affect the quality of time spent with others, a key determinant of individual well-being. This relational cost can be expected to become more relevant as smartphones become more widespread, more intrusive and smarter than ever. An important objective for future research is therefore to understand how *homo smartphoniens* can adapt to this new technology without letting it take away his relational dimension.

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