CHANGES AND VARIATIONS IN ONLINE AND OFFLINE COMMUNICATIONS PATTERNS: INCLUDING PEER EFFECTS

Complete Research

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Abstract

The impact of online communication on offline communication has received considerable research attention. Yet predominantly single level studies yield conflicting research findings and lack theoretical foundation. This study deviates from previous studies by developing a peer effect model rooted in Adaptive Structuration Theory (AST) in which the individual is embedded in social and technological structures. Offline communication is dependent on own online communication as well as the opportunities to connect with peers online. We argue that own online communication is only supplemental to offline communication if substitution is hampered by infrequent online communication of peers within the local environment as "it takes two to tango". Furthermore, frequent online communication of peers within the local environment results in a reduction in offline communication among users and non-users, resulting in non-users' social exclusion both online and offline. Our model predicts that substitution and exclusion effects become stronger as the internet is used for more divers forms of interactive communication. Results from our analysis using a multi-country dataset covering the years 2002 to 2012 provide empirical support for our model. We contribute to online communication literature with an AST perspective including on peer effects and technological change. Research and policy implications are discussed.

Keywords: Adaptive Structuration Theory, Peer effects, Online and offline communications

1   Introduction

The introduction and massive up take of the internet has dramatically impacted communication patterns (Boase et al., 2006). Consequently, research attention has been paid to the impact of online communication (i.e., interactive communication facilitated by the internet) on offline communication (i.e., face-to-face meetings) as well as overall social connectivity (DiMaggio, Hargittai, and Neuman, 2001). This interest is especially pronounced since the introduction of social media increased modes of online communication (Steinfield et al. 2012; boyd and Ellison, 2008). Recent studies find that online communication has allowed for new ways of organizing and maintaining individuals' pre-existing offline social networks (Donath, 2007), for example by allowing for daily interactions (Park, Kee, and Valenzuela, 2009). This interplay between online and offline communications in networks attracted recent research attention in the IS field (Zhang and Venkatesh, 2013; Kane and Alavi, 2014).

Despite the potential significance of the relationship between online and offline communication patterns to social connectivity, advancements in theorizing on the underlying mechanisms has remained limited (Kane and Alavi, 2014; Wilson, Gosling, and Graham, 2012; Majchrzak, 2009). One important issue that remains unresolved is how online and offline communications collectively impact social networks (based on Kane and Alavi, 2014). Considering the prevalence of online communication and its potentially important impact on social connections and thus social wellbeing, ambiguity about how online and offline communications relate to each other needs to be resolved.

The current study aims to reduce this ambiguity by focussing on changes and variations in relationships between online and offline communication patterns. We introduce and empirically study a peer effect model of online and offline communications. The model is based on adaptive structuration theory (AST) (DeSanctis and Poole, 1994) and predicts the individual level impact of online communication on offline communication depending on peer behaviour and historical shifts in online communication.

This paper contributes to our understanding of the relationship between online and offline communications in two ways. First, in line with AST, the model explicitly studies online and offline communications as a social phenomenon whereby individual communication outcomes are shaping as well as being shaped by group behaviours reflecting social structures (DeSanctis and Poole, 1994). Earlier studies usually studied the impact of online on offline communication as an individual, isolated phenomena (Zhang and Leung, 2014) and report conflicting findings (Lee, 2009). It has been suggested that the social context, for example network effects (e.g., peer effects), are a likely to be theoretical relevant (Zhang and Leung, 2014). Considering peer effects (Hartmann et al., 2008; Scheinkman, 2008) could reduce inconsistencies in research findings. In addition, such approach highlights the impact of online communication on not only users but also on non-users of online communication, a neglected research population in this literature ((Lampe, Vitak, and Ellison, 2013). Second, the current literature does not explain well how offline communication patterns changed as a consequence of technological change in online communication, e.g., introduction of social media. To address this issue, we assess of time trends in online on offline communication patterns. Thus far such assessments are limited and studies usually did not include more than 5 years of empirical data[1]. To assess time trends, our study includes the 2002-2012 period and treats the market entry of Facebook in Europe as an external shock that reflects major changes in patterns of online communication. In doing so we address the research question: *how do social structures, i.e., peer effects, in combination with technological change alter the effect of online communication on offline communication?*

We test our peer effect model based on a representative dataset covering 106,841 individuals from 111 regions in 12 European countries over the time period 2002 – 2012. We find that offline communication is positively related to online communication, irrespective of opportunities for and modes of online communication. However, the online communication of local peers decreases individual offline communication, and does so most pronouncedly when the opportunities for online communication increase, i.e., after the introduction of social media.

2 Theoretical Background and Prior Research

The online communication literature has often drawn on social capital theory to conceptualize the relationship between online and offline communications (see, for example, DiMaggio, Hargittai, Neuman, and Robinson, 2001; Ellison, Steinfield, and Lampe, 2011; Hampton, 2001; Hampton and Wellman, 2003; Wellman, Quan-Haase, Witte, and Hampton, 2001; Yang, Lee, and Kurnia, 2009). As a consequence, these studies tent to focus on either the community or individual level of analysis, neglecting the possibility that interaction between these two levels shape commination outcomes, which has led

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[1] For example: Brandtzæg (2012) includes the three years from 2008-10; Burke et al. (2011) include two years 2009 and 2010; Park (2011) includes three rounds of biannual data between 2000-4; Wang and Wellman (2010) cover the years between 2002-7 with two surveys; Valkenburg and Peter (2009) conducted two surveys in 2006; Miyata and Kobayashi (2008) Conducted three surveys between 2002-5; Steinfield, Ellison, and Lampe (2008) included two years 2006-7; Hampton (2007) three years 2002-4; and Lampe, Ellison, and Steinfield (2006) conducted two six months a part surveys between 2005-6

to inconsistent research findings (Lee, 2009). In this study, we use AST (DeSanctis and Poole, 1994) as underlying theoretical framework for our peer effect model of online and offline communications, while we draw on theoretical insights from the online communication literature to advance our arguments. Based on Giddens' (1984) structuration theory, AST helps to explain how different outcomes:

"result from the use of the same communication technology in groups. In particular, the theory focuses on the relationship between technology and the context in which technology is used. […] AST argues that, in the absence of any other intervention, individuals will tend to appropriate or use the technology in a manner that reinforces the rules and practices for interaction in their context" (Hill et al., 2009, p. 188).

A central premise in AST is the duality of structure: human action shapes, while at the same time is being shaped by, social structures (Giddens, 1984; Orlikowski, 1992). Key to this premise is the interplay between human behaviour, technology, and social structure (Cho and Lee, 2008).

In this study, we use AST to understand how human behaviour in the form of online and offline communications is shaped by its technological and social context. We argue that the relationship between online and offline communications is jointly shaped by technological change, for example the introduction of new online communication tools such as social media, and social structures. Social structures in this study focus on what DeSanctis and Poole (1994) refer to as 'styles of interacting' within the group's internal system. We provide a basic model of these relationships in Figure 1 and discuss the in the next sub-sections.
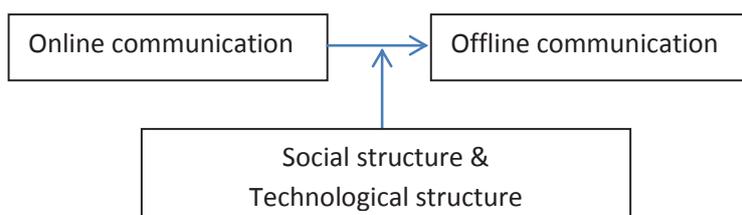

Figure 1.   An AST based model of the online-ffline communication relationship

2.1   Social structures shaping online and offline communications

AST proposes that the use of advanced information technologies varies across social contexts. For example, the way social groups communicate online may differ depending on the extent to which the appropriation of online communication is socially accepted and thus reinforces pre-existing rules and practices. Through recurrent, socially meaningful use of advanced information technologies, social groups produce and reproduce rules for present and future online communication. By doing so patterns of online communication, become institutionalized and start to shape future action (Orlikowski, 2000; DeSanctis and Poole, 1994; see also Wellman et al. 1996). In this way structures that were established through past group level interactions with the technology, enable subsequent patterns of online and offline communications and constrain others. Building on this idea, we argue that group acceptance of online communication moderate the impact of individual online communication on offline communication through peer effects.

Peer effects (Hartmann et al., 2008; Scheinkman, 2008) is "*present if the likelihood that a particular action will be used depends directly on the incidence of the action within some reference group*" (Agarwal, Animesh, and Prasad, 2009, p. 279). Peer effects are important to our understanding of the online/offline communication relationship, because individuals cannot socially interact in isolation of their peers (Putnam, 2000; Etzioni, 1995; 1993). For example, research has shown that when an online

network grows so does the social pressure to be active in that network (Antoci, Sabatini, and Sodini, 2013; 2012), moreover it increases opportunities for individuals in the online network to engage in online communication with peers. As such, peer effects are likely to change individual online communication patterns after online communication exceeds a particular threshold of popularity (Onnela and Reed-Tsochas, 2010).

Local, i.e. geographically close, peers are especially important for online and offline communications. First, for offline communication in the form of face-to-face contact interaction partners require geographical proximity of one another (Festinger, 1950). Moreover, despite some premature predictions of the 'death of distance' as a consequence of online communication (Caimcross, 2001; Wellman, 2001), recent studies suggest that online networks are, to a significant part, digital reflections of pre-existing offline, local networks (Tranos and Nijkamp, 2013; Takhteyev, Gruzd, and Wellman, 2012; Lampe, Ellison, and Steinfield, 2006). Therefore, local peers are likely to be the most relevant reference group for related patterns of online and offline communications.

In the next section we discuss the online communication literature that has largely disregarded the theoretically relevant peer effects (Zhang and Leung, 2014). We propose, based on a synthesis of online communication and peer effect literature, a peer effect model of online and offline communications.

2.2   A peer effect model of online and offline communications

Our peer effect model (see figure 2) relies on different levels and combinations of own and local peers' online communication to hypothesize three online and offline communications relationships: supplementing, substituting and socially excluding. *Supplementing* refers to a situation in which online communication is additional to and can occasionally spark offline communication. In this situation offline communication is positively affected by online communication. *Substituting* occurs when offline communication is replaced by online communication, i.e., own online communication has a negative effect on offline communication. Finally, we speak of *social exclusion* when offline communication is reduced, not by own online communication, but recurrent patterns of peer online communication. Below we analyse inconsistent findings presented in the online communication literature to develop three hypotheses on when supplementing, substituting and social exclusion occur.

Supplementing (top left quadrant, figure 2): The online communication literature has argued that online communication can supplement (Freberg et al., 2010; Tsao, 1996) or even complement offline communication, accelerating the returns of both (Zhang and Venkatesh, 2013; Hampton, Sessions, and Her, 2011; Wang and Wellman, 2010; Lee, 2009; boyd and Ellison, 2008; Kraut et al., 2002). Especially, social media use is often found to increase offline communication (Brandtzæg, 2012; Hampton, Sessions, and Her, 2011; Park, 2011 Vergeer and Pelzer, 2009; Hampton, 2007; Zhao, 2006).

We argue that online communication can indeed supplement or complement offline communication, but only in a situation where own online communication is frequent and local peers' online communication is infrequent. In this context, opportunities to engage in online communication is low as online communication tools have not passed the threshold of popularity (Onnela and Reed-Tsochas, 2010). The individual has thus few opportunities to engage in online interactions with local peers, but can communicate online with global peers enabling additional communication (i.e., supplementation). Occasionally, these global online interactions may result in additional offline communication with global peers (i.e., complementation).

H1:   *When local peers' online communication is low, individual online communication has a positive effect on offline communication.*
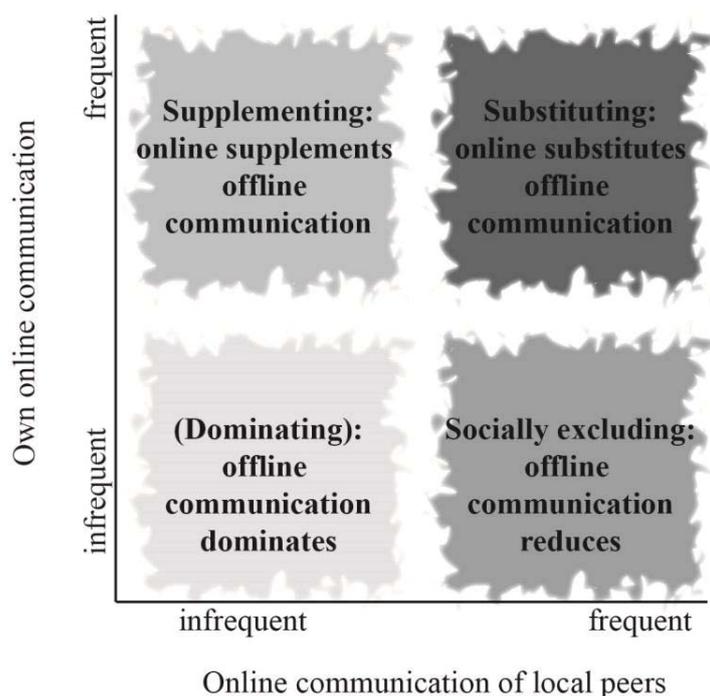
Figure 2.   A peer effect model of online and offline communications

Substituting (top right quadrant, figure 2): Interestingly, early online communication studies find that online communication does not supplement, but substitutes offline communication (Turle, 2011; Nie, Hillygus, and Erbring, 2002; Nie and Erbring, 2000; Putman, 2000; Kraut et al. 1998; Turkle, 1995). These studies rely on displacement theory, which is based on the relative constancy assumption (McCombs, 1972). The relative constancy assumption states that expenditures on mass communication remain constant over time (Emanuel et al., 2008). According to displacement theory, time spend online cannot be devoted to offline communication and thus offline communication reduces. Nie, Hillygus, and Erbring (2002) and Nie and Erbring (2000), for example, find that internet users spend less time on social and other activities. Also Kraut et al. (1998) following 73 households during their first years of internet use, report a negative effect on family communication and local contacts. Emanuel et al. (2008) refined the displacement argument by arguing that the time individuals spend on interactive communication is constant, irrespective of it occurs online or offline. Following this argument, online communication substitutes, rather than supplements offline communication, which implies a shift from offline to online communication.

The relative consistency assumption received little research attention within the (recent) online communication literature, whereas we believe it makes a valuable contribution to our current understanding of online and offline communications -at least under particular circumstances. When both own and local peers' online communication is high, the individual has the opportunity to engage in online communication with local peers (Antoci, Sabatini, and Sodini, 2013, 2012; Agarwal, Animesh, and Prasad, 2009). As the individual engages in online communication with local peers, some of these interactions may replace interactions that used to take place offline, i.e. offline communication is substituted by online communication. We therefore hypothesize:

H2:   *When local peers' online communication is high, individual online communication has a negative effect on offline communication.*

Social excluding (bottom right quadrant, figure 2): To the best of our knowledge no study assessing the impact of online communication on offline communication includes effects on non-users. Studies do assess how social capital of non-users differs from three user groups (Lampe, Vitak, and Ellison, 2013; Brandtzæg, 2012; Hargittai, 2008), but do not look at how non-users social capital changes as a consequence of others use. However, when online communication of peers can influence the relationship between individual online and offline communications, non-users could also experience a change in their offline communications without ever communicating online themselves.

We again build on the relative constancy assumption (McCombs, 1972) to argue that in environments where local peers' online communication is frequent, online communication replaces offline interactions among both users and non-users of online communication (Antoci, Sabatini, and Sodini, 2013; 2012; Agarwal, Animesh, and Prasad, 2009). Assuming local peers' expenditure (i.e., time) on mass communication remains constant irrespective of the media used, frequent online communication of local peers decreases opportunities for offline communication. Among non-users, unable to substitute offline with online communication, such replacement leads to reduced offline communication and thus social exclusion both online and offline.

H3:   *When local peers' online communication is high, non-use of online communication has a negative effect on offline communication.*

2.3   Technological structures shaping online and offline communications

In addition to social structures, AST elaborates on the role of the technological context, whereby advanced information technologies encourage different forms and patterns of communication depending on their structural potential, based on their technological features and spirit. This implies that the introduction of new online communication tools with new features and spirit is likely to foster new forms of communication, with the potential to alter the online-offline communication relationship. The introduction of social media provide an excellent example.

Social Media is "*a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content.*" (Kaplan & Haenlein, 2010, p. 61). On social media, all users can modify content in a participatory and collaborative fashion (Kaplan & Haenlein, 2010). Therefore, the social media introduction in Europe allowed for entirely new forms of highly interactive online communication. Following Emanuel et al. (2008), we hypothesize that when the variety of and opportunities for interactive online communication increase substitution effects become stronger (also see figure 3):

H4:   *The impact of local peers' online communication on own offline communication is most pronounced when opportunities for interactive online communication increase.*

3   Data and Empirical Approach

For this study we use data from the European Social Survey (ESS). The ESS is a biannual survey covering the time period 2002 to 2010 and because it covers a period in which internet use experience a major shift towards interactive communication it is well suited to test our theory. The ESS is one of
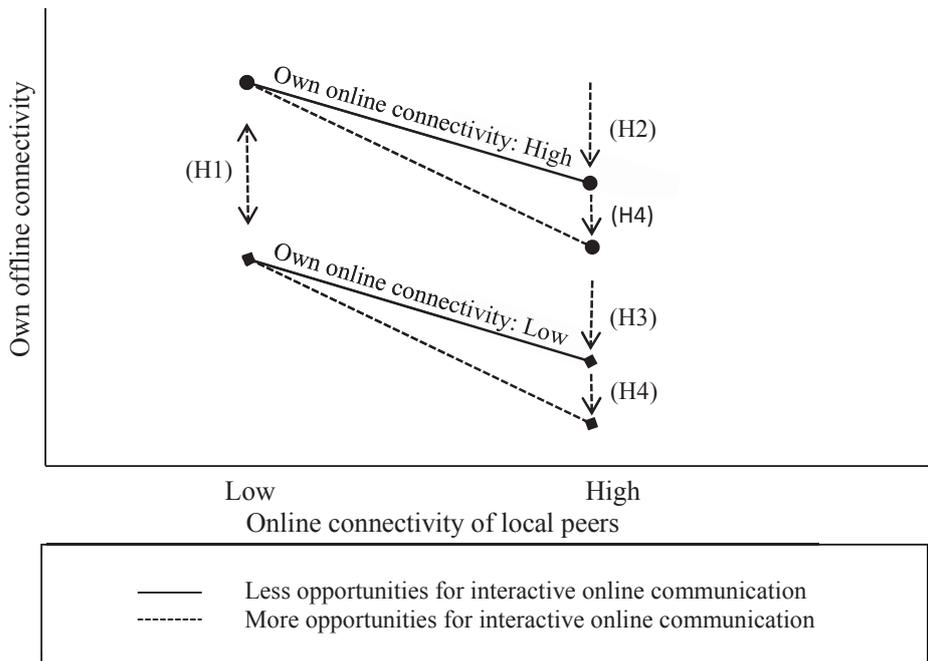
Figure 3.   *The effect of technological change on the online-offline communication relationship*

the most rigorous cross-country surveys with respect to methodological issues and contains data for several European countries (European Social Survey, 2012). We limit the initial sample to a set of countries and individuals for which all required variables were observed over the whole time period. The countries included in our analysis are Belgium, Switzerland, Estonia, Finland, Great Britain, Hungary, The Netherlands, Norway, Poland, Portugal, Sweden and Slovenia. Our dataset covers 106,841 individuals over five waves (2002 - 2010) and at the aggregate regional level data for our spatial analysis a total of 111 regions using data from all six waves (2002 – 2012) is covered. In our analysis we aim to disentangle the relationship between own online communication and online communication of local peers and own offline communication.

We estimate offline communication using the following equation

$$OffC_{ir} = \beta_0 + \beta_1 OnC_{ir} + \beta_2 \overline{OnC}_{(-i)r} + Z_{ir} + \varepsilon_i \qquad (1),$$

where OffC represents offline communication of individual i living in region r, OnC_i is online communication of the individual, and $\overline{OnC}_{(-i)r}$ represents the online communication of peers located in the same geographical area as individual I, i.e. local peers. Z denotes a vector of control variables. Estimation of the peer effect $\overline{OnC}_{(-i)r}$ is difficult since a number of issues may bias the result and make it difficult to interpret it as a causal effect (Manski, 1995). In absence of experimental data, we make use of technology driven external source of variation that allows more rigorous testing of our model. Specifically, we argue that a major change in online communication patterns in Europe was caused by an exogenous technological shock – the introduction of social media, which we estimate by the market

entry of Facebook in Europe.[2] In a very short time period social media usage became increasingly popular, creating new modes of online communication. We utilize this source of variation as an external "treatment" and introduce a dummy variable indicating if the survey interview took place after 2006, i.e. a social media introduction dummy based on the 2006 Facebook introduction in Europe. Next, we also consider the contingency of own and local peers' online communication by introducing an interaction term between these two variables. Finally, an interaction term is introduced to assess how own and local peers online communication is related to offline communication before and after the rise of social media. Thus, next to the own-peers online communication interaction, our final specification allows additional interactions between the social media introduction dummy and the intensity of own and local peers' online communication, as well as the three way interaction. The associated equation is

$$OffC_{ir} = \beta_0 + \beta_1 OnC_i + \beta_2 \overline{OnC}_{(-i)r} + \beta_3 OnC * \overline{OnC}_{(-i)r} + \beta_4 PostSM_i + \beta_5 PostSM_i * OnC_i +$$
$$\beta_6 PostSM_i * \overline{OnC}_{(-i)r} + \beta_7 PostSM_i * OnC_i * \overline{OnC}_{(-i)r} + Z_i + \varepsilon_i \qquad (2),$$

with *PostSM* taking on a value of unity for all observations after the year 2006. The coefficient β3 indicates the presence of an interaction between own and peers' online communication, β4 indicates the deviation in the relationship between online communication and offline communication after the year 2006, β5 represents the difference in the association between other peoples online communication and offline communication after the raise of social media, and β6 indicates if joint increases of own and peers' online communication affect offline communication differently after the introduction of social media.

Our dependent variable, offline communication, is proxied by assessing how often a person socially meets with friends, relatives or colleagues (i.e. face-to-face interactions, on a scale from 1-7). Because the ESS included no specific items related to the online communication, we apply personal internet use intensity and the introduction of social media as a conservative measure of changing patterns of internet use, i.e., increased modes of online communication. Internet use intensity was measured on a scale from 0 to 7, whereby '0' represents no internet access, '1' no use, and 7 daily use. The introduction of social media is a treatment variable that turns one if a person was interviewed after the introduction of social media in Europe (i.e. in 2006). Unfortunately, regional level data on the adoption rates of social media were not available. However, our approach provides a conservative estimate of the changing pattern and is likely to represent the lower bound of the actual effect. The set of control variables covers a variety of factors that can influence offline communication. We include socio-economic characteristics (e.g. age, gender, education and labour market participation), household characteristics (e.g. presence of partner and other household members, location of the household in a urban area), and country characteristics (GDP per capita and internet penetration rate).

4   Results

In this section we aim to disentangle changing and varying patterns between a person's own online and offline communications and local peers' online communication. We do so by looking at related

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[2] Facebook is currently one of the most popular social media in Europe 47% of the Western Europeans and 45% of the Eastern Europeans has an active account on Facebook, as compared to 45% in Eastern Europe (We are social, 2015). Based on the large uptake after the European launch, 2006 is the most adequate date to indicate a significant change in European online communication.

patterns of own and peer internet use and own offline communication before and after the introduction of social media. The results are reported in table 1. Model 1 to 6 are standard OLS regressions, while model 7 and 8 present the estimates of an Ordered Logistic Regression which accounts for the ordinal character of our dependent variable (See appendix A for the descriptive statistics).

We first estimate a model that only includes own internet use and local peers' internet use next to a set of control variables (Model 1). We observe that the relationship between own internet use and offline communication is positive while the relationship between local peers' internet use and offline communication is negative. This result suggest that there may be a trade-off between one's own and local peers' online communication. Next, we include our social media introduction dummy which turns out to be negatively related to offline communication (Model 2). This implies that average offline communication decreased significantly beginning with the 2006 period, as modes of online communication increased. In Model 3 we consider an interaction term between own and peers' internet use. This model is the first step towards an empirical model that is in line with our theory, since it assumes that a possible substitution effect requires simultaneous online communication of an individual and local peers. The sign of the interaction term is negative which is in line with our model. In Model 4 we introduce an interaction between own internet use and the social media introduction dummy. The interaction term is negative but only significant at the ten percent level. Due to the large sample size we do not consider this enough evidence that the positive correlation between own internet use and offline communication decreases when the modes of online communication increase (i.e., after the introduction of social media). Model 5 introduces an interaction term between local peers' internet use and the social media introduction dummy. The negative and significant coefficient for this interaction indicates that the strength of the negative association between local peers' internet use and own offline communication becomes stronger as modes of online communication increase. The sign of the social media introduction dummy reverses in this specification which implies that after the introduction of social media for the (unrealistic but interesting) situation that local peers' would not use the internet at all, offline communication would have increased.

In model 6 we allow for a three-way interaction. First, own and local peers' internet use is allowed to vary in the pre and post social media introduction period. Second, the joint effect of own and local peers' internet use is allowed to vary in the pre and post period as well. Due to the interaction terms the variables for own internet use, internet use of peers, and the post social media introduction dummy cannot be interpreted separately. Therefore, we calculated predictions for different scenarios: Two types of individuals – an individual with high and low internet use - that live in two different regions – an high and low use environment. The high and low use environments are based on the 25% and 75% percentile of the local peers' internet use distribution. We define individuals with high internet use as individuals who use the internet several times a week or more and individuals with low internet use as individuals who use the internet less than once a month. The predictions are estimated using model 6 and are documented in Figure 4.

Generally, we observe that own internet use is positively correlated with offline communication. This may be attributed due to supplementing and complementing effects of online communication. More interestingly, we find that offline communication in low use environments does not differ before and after social media introduction. These findings are in line with the prediction of our theoretical model since it posits that decreasing offline communication is due to peer effects. Moreover, a high use environment reduces offline communication significantly. This reduced offline communication is more pronounced for individuals with high internet use. Also this finding is in line with our theoretical predictions since such an environment does allow for substitution effects. Our theoretical model also suggest that the substitution potential in high use environments will be more pronounced when opportunities for online communication increase, i.e., after social media introduction. Our empirical results indi-

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	Ordinary Least Squares (OLS)						Ordered Probit	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Own online communication	0.0542***	0.0560***	0.0808***	0.0583***	0.0555***	0.0788***	0.0584***	0.0759***
	(0.00218)	(0.00218)	(0.00605)	(0.00250)	(0.00218)	(0.00756)	(0.00313)	(0.00976)
Peer online communication	-0.140***	-0.0904***	-0.0659***	-0.0901***	-0.0335***	-0.00305	-0.0667***	-0.0480***
	(0.00979)	(0.0104)	(0.0123)	(0.0104)	(0.0113)	(0.0138)	(0.0141)	(0.0173)
Own online communication* Peer online communication			-0.00669***			-0.00811***		-0.00531**
			(0.00150)			(0.00207)		(0.00266)
Post social media * Own online communication				-0.00576*		-0.0322**	0.00868**	-0.0390*
				(0.00341)		(0.0154)	(0.00434)	(0.0207)
Post social media * Peer online communication					-0.122***	-0.170***	-0.166***	-0.212***
					(0.0108)	(0.0197)	(0.0146)	(0.0256)
Post social media * Own online communication* Peer online communication						0.0114***		0.0122**
						(0.00364)		(0.00480)
Post social media (1=Yes)	-0.199***	-0.199***	-0.194***	-0.175***	0.299***	0.427***	0.434***	0.606***
	(0.0112)	(0.0112)	(0.0113)	(0.0199)	(0.0475)	(0.0806)	(0.0632)	(0.107)
Age	-0.0160***	-0.0157***	-0.0158***	-0.0157***	-0.0157***	-0.0157***	-0.0199***	-0.0199***
	(0.000357)	(0.000357)	(0.000358)	(0.000358)	(0.000357)	(0.000358)	(0.000449)	(0.000450)
Years of education	-0.0185***	-0.0207***	-0.0209***	-0.0206***	-0.0197***	-0.0199***	-0.0295***	-0.0294***
	(0.00136)	(0.00137)	(0.00137)	(0.00137)	(0.00136)	(0.00137)	(0.00170)	(0.00170)
Working hours	-0.00624***	-0.00620***	-0.00615***	-0.00620***	-0.00617***	-0.00613***	-0.00890***	-0.00888***
	(0.000302)	(0.000303)	(0.000303)	(0.000303)	(0.000302)	(0.000303)	(0.000391)	(0.000391)
Gender (1 = male)	0.0730***	0.0700***	0.0694***	0.0697***	0.0705***	0.0708***	0.103***	0.103***
	(0.00983)	(0.00983)	(0.00983)	(0.00983)	(0.00981)	(0.00982)	(0.0122)	(0.0122)
City (1 = Yes)	-0.0334**	-0.0313**	-0.0297**	-0.0314**	-0.0305**	-0.0298**	-0.0174	-0.0175
	(0.0137)	(0.0137)	(0.0137)	(0.0137)	(0.0136)	(0.0136)	(0.0168)	(0.0168)
Unemployed (1=Yes)	-0.0950***	-0.0775***	-0.0748***	-0.0774***	-0.0812***	-0.0798***	-0.0952***	-0.0944***
	(0.0274)	(0.0274)	(0.0274)	(0.0274)	(0.0273)	(0.0273)	(0.0338)	(0.0338)
Partner in household (1 = Yes)	-0.383***	-0.386***	-0.382***	-0.386***	-0.387***	-0.386***	-0.560***	-0.560***
	(0.0103)	(0.0103)	(0.0103)	(0.0103)	(0.0103)	(0.0103)	(0.0130)	(0.0130)
No of other household members	-0.0417***	-0.0377***	-0.0374***	-0.0377***	-0.0371***	-0.0368***	-0.0373***	-0.0371***
	(0.00427)	(0.00427)	(0.00427)	(0.00427)	(0.00427)	(0.00427)	(0.00542)	(0.00542)
GDP per capita	2.09e-05***	1.98e-05***	2.01e-05***	1.99e-05***	2.10e-05***	2.11e-05***	2.54e-05***	2.53e-05***
	(4.21e-07)	(4.18e-07)	(4.20e-07)	(4.18e-07)	(4.28e-07)	(4.28e-07)	(5.42e-07)	(5.42e-07)
Internet penetration rate	-0.000979	-0.000732	-0.00108*	-0.000826	-0.00280***	-0.00297***	-0.00288***	-0.00298***
	(0.000637)	(0.000636)	(0.000640)	(0.000635)	(0.000647)	(0.000648)	(0.000807)	(0.000808)
Constant	6.250***	6.166***	6.099***	6.161***	6.051***	5.980***	0.142***	-5.655***
	(0.0342)	(0.0346)	(0.0394)	(0.0348)	(0.0362)	(0.0426)	(0.0471)	(0.0618)
R-Squared	0.123	0.125	0.126	0.126	0.128	0.129		
AIC							355673.7	355667.8

Note: Robust standard errors in parentheses. Significant at *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The number of observations is 106,841.

Table 1.   *The relationship between own and local peers' online communication and offline communication*

cate such a trend as offline communication significantly decreases after the introduction of social me-dia, but only in high use environments. Interestingly, individuals who rarely use the internet exhibit the strongest decrease in offline communication when their local peers start to use the internet more frequently. The estimated decrease in offline communication for this group is 0.32 after the introduc-tion of social media while we only observe a decrease of 0.23 for individuals with high internet use. Consequently, and despite increased modes of online communication, our results suggest that not communicating online in environments where online communication is frequent may cause social ex-clusion. Overall, these insights support our claim that the relationship between online and offline communication patterns needs to be conceptualized as a social phenomenon, involving other people.
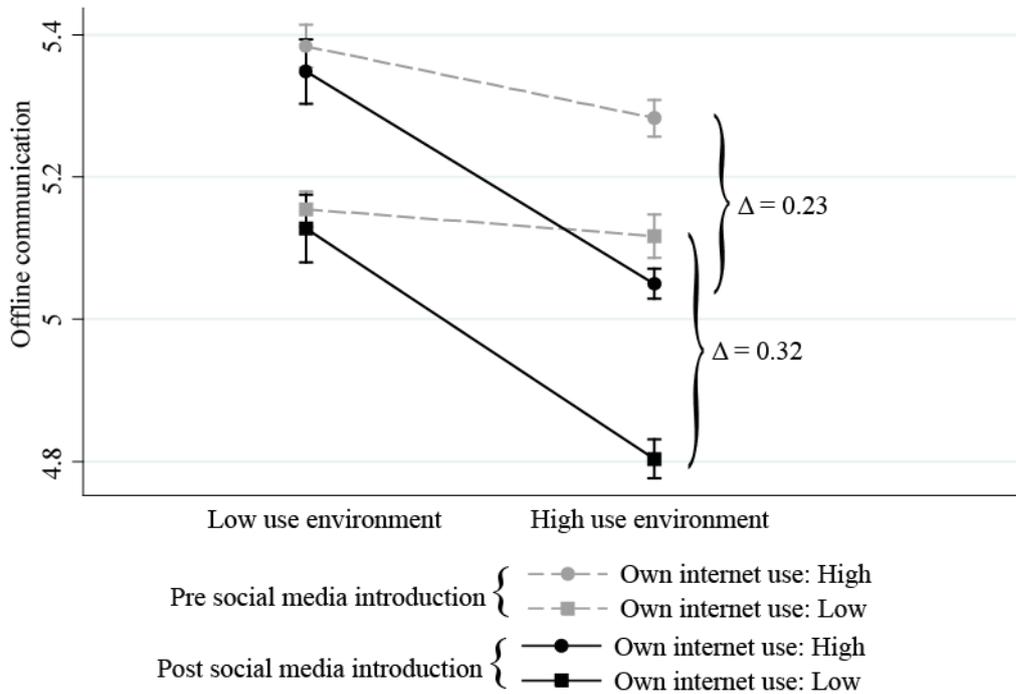

Figure 4.   *Offline communication for individuals with high/low internet use in high/low use envi-ronments pre and post social media introduction (linear predictions with 95% confi-dence intervals)*

5   Discussion

Therefore, this study was motivated by the wish to better understand the impact of online communica-tion on offline communication, as previous literature yielded inconsistent findings (Lee, 2009). For this, we looked at changes and variations in the relationships between online and offline communica-tion patterns from a AST perspective. First, we identified three streams of literature building on sup-plementation, substitution, and displacement augments respectively and thus with divers views on the online/offline communication relationship. Second, drawing on AST based-propositions, we devel-oped the peer effect model to argue that deviating views of the impact of online communication on offline communication are all valid, but only under particular socio-technical circumstances. In doing so, we contributed to the online communication literature that largely ignored potentially relevant so-cio-technical aspects of online communication (Zhang and Leung 2014; DeSanctis and Poole, 1994). The model takes into consideration peer effects, and the moderating effect of increased opportunities for online communication after the introduction of social media.

Next we summarize the empirical analyses. Our findings show that the peer effect model explains changes and variations in online and offline communication patterns. It thus reduces the theoretical ambiguity that follows from inconsistent research findings in online communication literature. We conclude by addressing research and policy implications as well as the limitations of this study.

5.1   Empirical findings largely support our hypotheses

Empirical results largely supported the four hypotheses developed from our peer effect model. H1 is supported as we found that individual level online communication is positively related to offline communication, even when online communication of local peers is controlled for. This is in line with findings in online communication studies arguing online communication and especially social media use has a positive effect on offline communication (Brandtzæg, 2012; Hampton, Sessions, and Her, 2011; Park, 2011 Vergeer and Pelzer, 2009; Hampton, 2007; Zhao, 2006). H2 also found support. Results showed that individual online communication has negative effect on offline communication when the online communication of local peers is high. Indeed, peer effects are found to not only affect adoption of the internet (Agarwal et al. 2009; Antoci et al., 2013, 2012)., but also online and offline communication patterns. Results suggested that local peers' online communication creates opportunities to communicate online. We find partial support for H3, i.e., only when opportunities for interactive online communication increase, i.e. after the introduction of social media, local peers' online communication negatively impacts offline communication of non-users. Considering social implications of social media non-users can thus not be neglected (Lampe, Vitak, and Ellison, 2013; Brandtzæg, 2012; Hargittai, 2008). Finally, H4 is supported. We found that the impact of both own and local peers' online communication on offline communication has become stronger, i.e. more negative, when opportunities for interactive online communication increase (Emanuel et al., 2008), i.e., after the introduction of social media.

5.2   AST contributions to online communication literature

AST (DeSanctis and Poole, 1994) informs our main conclusions and contributions to the online communication literature. First, in line with previous literature on online communication we conclude that online and offline patterns of communication are closely related (Boase et al., 2006; Donath, 2007; Park et al., 2009; Zhang and Venkatesh, 2013; Kane and Alavi, 2014). Next, we observe that variations in combined online and offline communication patterns result from peer effects (Hartmann et al., 2008; Scheinkman, 2008). Interpreting these results from an AST perspective, we find that when individuals, as social actors, are confronted with new advanced information technologies they start using these technologies in ways that confirm pre-existing patterns of interaction within the social group. This implies that social norms, rules, and resources enacted in peer online communication practices enable and constrain individual appropriation of the technology (DeSanctis and Poole, 1994), resulting in supplementation, substitution, or social exclusion. Finally, online and offline communication patterns change over time as a consequence of innovations in advanced information technologies. Following DeSanctis and Poole (1994), the introduction of new online communication tools extents the structural features available for online communication. Moreover it promotes new perspectives on the online communication form enabled by the new tool. Depending on the possible synergies between pre-existing socio-technical structures and the structures enabled by the new technology, social actors will appropriate the tool in different ways. Our finding that increasing opportunities for interactive online communication (McCombs, 1972; Emanuel et al., 2008) reinforce substituting and excluding effects of peer online communication, is in line with this argument. Overall, we find that AST provides a rich basis to further deepen and connect important and relevant theoretical insights from the online communication literature.

5.3   Research and policy implications

As online communication becomes more and more prominent in many societies, our model suggest that the relevance of supplementing effects is likely to diminish. Instead, substituting and social excluding effects become more prominent. Our findings support the relative constancy assumption applied to interactive communication (Emanuel et al., 2008; McCombs, 1972). We suggest that this assumption deserves renewed attention in the online communication literature. Building on the existing knowledge within the online communication literature, the relative constancy assumption provides an enhanced perspective on the relationship between online and offline communications. In addition, our

findings may be of interest to media studies analysing patterns of news consumption via offline (paper), online, and mobile media (Westlund & Färdigh, 2011; 2015). Although peer effects may be less pronounced, social influence (Schmitz and Fulk, 1991; Fulk, Schmitz, and Steinfield, 1990; 1987) might also play a role in news consumption, especially when readers are actively online commenting on news items. Moreover, patterns of online and offline news consumption may change due to the introduction of new technologies, e.g., mobile news applications in addition to online news sites (Westlund & Färdigh, 2011; 2015).

Moreover, our findings certainly matter, both from a theoretical and societal perspective, for the social position of non-users of online communication within increasingly digitalizing societies. This study shows that as technological change allows for more interactive forms of online communication, non-users become socially excluded. Social exclusion may hamper social wellbeing (WHOQoL group 1995) and therefore overall wellbeing (Skevington, Lotfy, O'Connell, 2004). Extending the digital divide argument (Agarwal, Animesh, and Prasad, 2009; Katz and Aspen, 1997), we argue that socio-economic differences are not only reflected in internet adoption patterns. In addition, the peer online communication negatively affects non-users offline communication. Therefore, unequal internet and online communication adoption patterns does not only help "the rich get richer" (Lee, 2009; Kraut et al. 2002), in addition the poor are getting poorer. As a consequence, non-use reinforces pre-existing socio-economic inequalities between individuals (see DeSanctis and Poole, 1994).

Concerns about the social exclusion of non-users are all the more pressing, because technological change increases the opportunities for interactive online communication. Our findings show that increasing opportunities for interactive online communication, illustrated by the introduction of social media, accelerates substitution and exclusion effects.

An important policy implication of our findings the importance of increased awareness of societal communication patterns. Policy makers planning interventions to increase online communication need to carefully consider the social context in which they are intervening in and the desired outcomes of such interventions. For example, interventions to increase online communication in environments where online communication is common may not lead to increased communication, rather online communication patterns are likely to substitute their offline counterparts. This may be a desired outcomes when planning to reduce communication costs, but not when battling loneliness among older adults. Careful consideration of the intervention goals is therefore important. Moreover, in digitizing societies individuals that do make use of online communication applications are not only excluded from online communication, but also from offline communication. In addition to being socio-economically disadvantaged (Agarwal, Animesh, and Prasad, 2009; Katz and Aspen, 1997), these non-users experience a decline in offline communication, widening the digital divide between users and non-users. These implications are a particular cause for concern as not only social interactions (Boase et al., 2006; Donath, 2007), but also societal participation (Howard et al., 2011) and (health) services (e.g. AAL, 2012) shift towards the online domain at the expense of the offline domain. Policy makers need to take into consideration these potentially excluding effects.

5.4   Limitations

This study has some limitations. First, we acknowledge that internet use is an imprecise measure of online communication. Second, while we acknowledge the endogenous character of peer effects, this study makes use of the relatively late arrival of Facebook in Europe to study how internet use of an individual embedded in her environment impacts offline connectivity**.** Third, since shifts in internet use towards social media is an endogenously determined process we used the arrival of Facebook in Europe as an exogenous shock in which a major player entered the market for social media resulting in different (i.e., more social) patterns of internet use. However, the endogenous process of shifts in internet use deserves further attention. Fourth, the causal interpretation of our analyses is limited. Finally, our study does not distinguish between different types of social ties (Burt, 1992; Wasserman and Faust, 1994; Granovetter, 1983). We suggest future research analyses how different social ties are shaped through online and offline communications in different social and technological contexts.

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Appendix A

Variable	Mean	Std. Dev.	Min	Max
Offline communication	5.112202	1.547067	1	7
Post SM	.4154927	.4928091	0	1
Own online communication	3.816705	3.022619	0	7
Peer online communication	3.733444	1.210922	.25	6.26316
Age	46.01235	18.27114	14	123
Years of education	12.01444	4.165545	0	30
Working hours	35.88452	17.65016	0	100
Gender (1 = male)	.4759795	.499425	0	1
City (1 = Yes)	.1565512	.3633788	0	1
Unemployed (1 = Yes)	.0375014	.1899878	0	1
Partner in HH (1 = Yes)	.632794	.4820456	0	1
No of other HH members	2.304332	1.433679	0	19
GDP per capita	35193.3	17947.16	5183.8	93156.8
Internet penetration rate	63.97332	19.55935	16.67	93.39

Table A1.   Summary statistics