Bowling alone but tweeting together: the evolution of human interaction in the social networking era

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Bowling alone but tweeting together: the evolution of human interaction in the social networking era

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Abstract

The objective of this paper is to theoretically analyze how human interaction may evolve in a world characterized by the explosion of online networking and other Web-mediated ways of building and nurturing relationships. The analysis shows that online networking yields a storage mechanism through which any individual contribution - e.g. a blog post, a comment, or a photo - is stored within a particular network and ready for virtual access by each member who connects to the network. When someone provides feedback, for example by commenting on a note, or by replying to a message, the interaction is finalized. These interactions are asynchronous, i.e. they allow individuals to relate in different moments, whenever they have time to. When the social environment is poor of participation opportunities and/or the pressure on time increases (for example due to the need to increase the working time), the stock of information and ties stored in the Internet can help individuals to defend their sociability.

Keywords: Internet, computer-mediated communication, online networking, Facebook, social networks, social capital.

JEL Codes: O33, Z13

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1. Introduction

Were it not for the Internet, Barack Obama would not be president. Were it not for the Internet, Barack Obama would not have been the nominee, said Arianna Huffington, editor in chief and co-founder of The Huffington Post, the most popular American news website. Mr. Obama used the Internet to organize his supporters in a way that in the past would have required an army of activists and paid organizers on the ground. Through social networking sites (SNSs) such as Facebook, YouTube, and Twitter, he was able to mobilize thousands of people. The Obama campaign also caused a sea change in fact-checking, with citizens using the Internet to prove a politician wrong and then using SNSs to alert their fellow citizens. But SNSs have not changed only political life. In the last five years, they have literally revolutionized our lives. Social networking has made it simpler to interact with others without the limitations of geography and lack of time. In this paper, consistent with results from recent studies in the fields of applied psychology and communication science, we argue that Web-mediated interaction can play a major role in the preservation and development of interpersonal relations (Subrahmanyam et al. 2008; Park et al. 2009; Matzat 2010; Pénard and Poussing 2010; Bauernschuster et al. 2011; Gil de Zúñiga et al. 2011).

Participation through online networks can help individuals to maintain their social contacts from distant locations, for example after a transfer due to work commitments (Cummings et al. 2006; Ellison et al. 2007; 2011). Moreover, Web-mediated interaction is less sensitive to a reduction in leisure time caused by an intense pace of work. Facebook and Twitter allow users to stay in touch with their friends and acquaintances during coffee breaks or while waiting for the train. Online social participation favours asynchronous interactions which allow individuals to compensate for the lack of time: one can benefit from the others' participation, for example by reading a message or a note, even if the person who wrote it is currently offline. It is noteworthy that asynchronous interactions are not necessarily of inferior quality compared to simultaneous, face-to-face, interactions. Experiments found that the depth of a friendship can be significantly improved by computer-mediated communication. Apparently, by way of online relationships individuals become far better in expressing their true selves and feelings (Ellison et al. 2007; Park et al. 2009b; Burke et al. 2010; Sheldon 2010; Burke and Settles 2011). Interactions through the Internet can foster the social inclusion of individuals suffering from social anxiety, i.e. anxiety about social situations, interactions with others, and being evaluated by others (Caplan 2007; Steinfield et al. 2008). Thanks to new tools such as Facebook messages and Flickr mails, many people have regained the habit of writing letters. Psychological studies claim this form of interaction can lead to an improvement in the quality of relationships. Letters have in fact been found to have the property of slowing the communication down, thus giving people more time and reasons to process their feelings, to put a greater effort into understanding others' expectations, and to think in depth before they respond (Kobayashi and Ikeda 2008; Miyata and Kobayashi 2008; Steinfield et al. 2008).

In addition to the preservation of existing ties, interaction through SNSs can foster the creation of new relations. Everyday life experience shows that a rising number of Internet users are forming closer relationships with individuals they first met online. Some SNSs serve the explicit purpose of favouring physical encounters between members. For example, Academia.edu was conceived to make authors meet and work together on new projects, LinkedIn aims to foster a better matching between workers and employers in the job market, and Meetic is now a reference point for individuals aiming to build a romantic relationship.

Last but not least, Web-mediated interaction contributes to the building of what has been called Internet social capital, i.e. the accumulation of a stock of knowledge, information and trust within virtual networks (Gaudel and Peroni 2008; Vergeer and Pelzer 2009; Chaim and Gandal 2010; Gaudel et al.

2010; Matzat 2010; Antoci et al. 2011a) [5].
The phenomena briefly described above suggest that the Internet can help mitigate the decline in social participation which has been documented in a number of empirical studies (Paxton 1999, Putnam 2000, Robinson and Jackson 2001, Costa and Kahn 2003, Bartolini et al. 2011). From this point of view, social participation through the Internet could be considered as a defensive behaviour, which allows individuals to protect their relationships from increasing time pressures and from the possible decrease in the probability of in-person encounters offered by the social environment physically surrounding the individual (Antoci et al. 2011a). The spread of this mode of participation can lead to second-best scenarios, in the case that face-to-face interaction is socially optimal. However, as shown in Antoci et al. (2011b), it may prevent the economy from falling into a social poverty trap.

The objective of this paper is to theoretically analyze how human interaction may evolve in a world characterized by the explosion of online networking and other Web-mediated ways of building and nurturing relationships.

To reach this goal, we build a theoretical framework where agents can develop their social interactions through two different strategies: 1) A social networking strategy (hereafter *SN*), within which social participation takes place both by means of online networking and face-to-face interaction. For example, when they are too busy to arrange physical encounters, individuals playing *SN* stay in touch with their relatives and friends through SNSs, but they meet them in person every time they can. 2) A face-to-face strategy (hereafter *FF*), which does not encompass social interaction through the Internet.

The analysis shows that Web-mediated interaction yields a storage mechanism through which any individual contribution - e.g. a blog post, a comment, or a photo - is stored within a particular network and virtually ready for use to each member who connects to the network. When someone provides feedback, for example by commenting on a note, or by replying to a message, the interaction is finalized. These interactions are asynchronous, i.e. they allow individuals to relate in different moments, whenever they have time to (e.g. in the night, just before going to sleep). When the social environment is poor in opportunities for participation and/or the pressure on time increases (for example due to the need to increase working hours, the social capital stored in the Internet can help individuals to defend their sociability. In other words, the relative performance of the two strategies of participation is influenced by the rise in the pressure on time. Social interaction through the Internet can thus help protect the relational sphere of individuals' lives from space and time constraints. Since the consumption of relational goods has been found to exert a significant influence on happiness (Gui and Sugden 2005; Becchetti et al. 2008; Bruni and Stanca 2008; Becchetti and Degli Antoni 2010), our results suggest that, under certain conditions, Internet usage can support well-being by counterbalancing the effects of time pressure on mental distress and the disruption of social ties. This result is consistent with recent empirical findings showing the existence of a significant and positive correlation between Internet usage and happiness (Pénard et al. 2011; Sabatini 2011).

Our work has relevant theoretical and policy implications. First, we provide theoretical research with a logical framework for analyzing the relationship between web-mediated communication, the evolution of human interaction and the accumulation of social capital. Second, the analysis is also related to the

[5] In addition to SNSs, the accumulation of information seems to be particularly evident in sites such as Tripadvisor and Zagat, where users review their experience with hotels, restaurants, airlines and travel agencies with no self-interested purposes may be able to nurture the diffusion of trust in strangers among travellers. However, it is noteworthy that the usefulness of online networks in the diffusion of information and trust has been questioned for groups where members are anonymous and their tastes are actually unknown (see for example Demange (2010). Penard (2011) finds that reputation feedback systems significantly improve the diffusion of trust in e-marketplaces, but are vulnerable to strategic ratings and reciprocation.

literature on the digital divide (Goldfarb and Prince 2008; Agarwal et al. 2009; Drouard 2010). If the adoption of the SN strategy can support happiness through engagement in social activities, then Internet users could increase their subjective well-being compared to non-users, especially when the pressure on time increases. As recently remarked by Pénard et al. (2011) and Sabatini (2011), high income individuals tend to be happier and to use the Internet more than low income people. Thus, the digital divide may increase existing inequalities in subjective well-being. From the policy point of view, this suggests that the reduction in the digital divide could be an effective measure to contain inequalities in the distribution of well-being.
The remainder of the paper is as follows: in the next section we review the social science literature on the role of SNSs in the evolution of social interaction. In section three we present our framework. Section four discusses the implications of this framework. The paper is closed by a few concluding remarks and considerations for further studies.

2. Related literature

Early sociological studies on computer-mediated communication shared the fear that the Internet would cause a progressive reduction in social interactions, just as the activity of watching TV does (Bruni and Stanca 2006; 2008; Frey et al. 2007). The main argument shared by Internet skeptics was based on the presumption that the more time people spend using the Internet during leisure time, the more time has to be detracted from social activities (Katz et al. 2001; Nie et al. 2002, Attewel et al. 2003; Gershuny 2003; Robinson and Martin 2010). However, studies emphasizing the negative correlation between Internet usage and sociability date back to just shortly before the explosion of online networking, and they could not differentiate between pure entertainment and social activities[6]. At that time, using the internet was predominantly an individual activity like watching TV or reading newspapers. Today, the use of the internet is strongly related to being connected to social networking sites, which in turn entails forms of engagement in social activities. According to data on the U.S. provided by the Internet & American Life Project carried out by the Pew Research Center (PRC), as of September 2009 nearly three quarters (73%) of online teens (aged 12-17) and an equal number (72%) of young adults (18-29) used social network sites. A recent survey conducted in the U.S. in May 2011 found that fully 65% of online adults now use social networking sites. This figure marks a dramatic increase from the first time the Project surveyed usage of social networking sites in February of 2005. At that time just 8% of internet users or 5% of all adults said they used SNSs (Madden and Zickuhr 2011). In December 2010, U.S. Internet users were found to be more likely than others to be active in some kind of voluntary group or organization: 80% of American Internet users participate in groups, compared with 56% of non-Internet users. Moreover, social media users are even more likely to be active: 82% of social network users and 85% of Twitter users are group participants (Rainie et al. 2011). This evolution makes any comparison between the internet and TV anachronistic.
Pessimistic views on the social effects of Internet usage have already been challenged by results from pioneer studies specifically targeted at verifying the effects of online networking on communities living in a precise geographic location (e.g. a city area, a rural village, or a suburb). Drawing on survey and ethnographic data from a wired suburb of Toronto, Hampton and Wellman (2003) find that high-speed, always-on access to the Internet, coupled with a local online discussion group, transforms and enhances "neighbouring". In particular, the internet supports increased contacts with weaker ties, without causing

[6] Robinson and Martin (2010) use data from the 2006 wave of the General Social Survey, which were collected in 2005, just shortly before the explosion of online networking.

any deterioration in strong ties. In the authors' words, "not only did the internet support neighbouring, it also facilitated discussion and mobilization around local issues" (Hampton and Wellman 2003, p. 277). Kavanaugh et al. (2005) find that computer-mediated interactions have positive effects on community cohesion, involvement, and social capital in the village of Blacksburg, Virginia. In one of the first economic studies on the topic, based on a longitudinal survey conducted in 1998 and 2001 among a random sample of Swiss citizens, Franzen (2003) finds that Internet use is not associated with a reduction in respondents' networks or in the time they spent socializing with friends. Instead, the time users devote to the Internet is taken away from the time spent on watching television.

2.1 Recent studies

Findings from the latest wave of studies (i.e. carried out between 2007 and 2011) on the relational effects of social networking further challenge the earlier concerns about the socially detrimental effects of the Internet. These studies almost unanimously converge on the claim that online networks support the consolidation and development of existing ties[7]. As emphasized in the review of the literature carried out by Antoci et al. (2011a), the main reason why these works appear to be more reliable than those that argue for a possibly negative relationship between computer-mediated interaction and social capital is that they were conducted *after* the explosion of online networking. Thus, they take into account the social implications of SNS usage. It is also remarkable that some studies on Facebook rely on server log data provided by the platform itself, which provides large samples, higher representativeness, objective information on what people really do on the platform, allowing for the distinction between social activities and individual pastimes like taking quizzes (see for example Burke et al. 2010; 2011).

According to this strand of the literature, SNSs support the strengthening of bonding and bridging social capital (Steinfield et al. 2008, Park et al. 2009; Pénard and Poussing 2010; Bauernschuster et al. 2011), allow the crystallization of weak or latent ties that might otherwise remain ephemeral (Haythornthwaite 2005, Ellison et al. 2007: 2011; Miyata and Kobayashi 2008), facilitate the establishment of new collaborations in the academic community (Matzat 2004), support teenagers' self-esteem - encouraging them to relate to their peers (Ellison et al. 2007; 2011; Steinfield et al. 2008), stimulate social learning (Burke et al. 2010), enhance social trust (Matzat 2010), civic engagement (Stern and Adams 2010; Zhang et al. 2010) and political participation (Gil de Zúñiga et al. 2011), facilitate the creation of electronic networks of practice (Vasko and Faray 2005), and help the promotion of collective action (Landqvist and Teigland 2010).

Drawing on survey data from a random sample of 800 undergraduate students, Ellison et al. (2007) find that certain types of Facebook use can help individuals accumulate and maintain bridging social capital. The authors suspect that the social network helps students to overcome the barriers to participation so that individuals who might otherwise shy away from initiating communication with others are encouraged to do so through the Facebook infrastructure. In the authors' words, highly engaged users are using Facebook to "crystallize" relationships that might otherwise remain ephemeral (2007). Haythornthwaite (2005) argues that social media create latent tie connectivity among group members that provides the technical means for activating weak ties (p. 125). Latent ties are those social network ties that are technically possible but not activated socially (p. 137)[8].

[7] A reading list on the relationship between Internet usage and social interactions is available on the web site Social Capital Gateway at the url http://www.socialcapitalgateway.org/internet

[8] According to Ellison et al. (2007), Facebook might make it easier to convert latent ties into weak ties, in that the site provides personal information about others, makes visible one's connections to a wide range of individuals, and enables students to identify those who might be useful in some capacity, thus providing the motivation to activate a latent tie.

Steinfield et al. (2008) analyzed panel data from two surveys on Facebook users conducted a year apart at a large U.S. university. Intensity of Facebook use in year one strongly predicted bridging social capital outcomes in year two, even after controlling for measures of self-esteem and satisfaction with life. The authors suggest that Facebook affordances help reduce barriers that students with lower self-esteem might experience in forming the kinds of large, heterogeneous networks that are sources of bridging social capital.
However, the growing literature on Facebook suggests that the social network - and, more generally, Internet-mediated communication - serves more the preservation of relations among offline contacts than the activation of latent ties or the creation of connections with strangers (Ellison et al. 2007; Lampe et al. 2006). Most Facebook friend connections indeed represent in-person relationships (Ellison et al. 2011). In one of the rare economic studies on the topic, Pénard and Poussing draw on data from the 2002 wave of the European Social Survey (EVS) for Luxembourg to find that people who already have a large stock of social capital are more likely to use the Internet to take care of their social relationships. In a recent paper based on data drawn from the 2008 section of the German Socio-Economic Panel and confidential data provided by *Deutsche Telekom*, Bauernschuster et al. (2011) find that having broadband Internet access at home has positive effects on the frequency of visiting theaters, the opera, and exhibitions and on the frequency of visiting friends, even after controlling for endogeneity through instrumental variables estimates and by accounting for county fixed effects. Exploring a sub-sample of children aged 7 to 16 living in the sampled households, the authors further find evidence that having broadband Internet access at home increases the number of children's out-of-school social activities, such as doing sports or ballet, taking music or painting lessons, or joining a youth club.
Since engagement in relational activities and social capital are positively correlated with happiness (Becchetti et al. 2008; Bruni and Stanca 2008; Gui 2010; Stanca 2010; Bartolini et al. 2011), Internet usage could also have a positive effect on individual well-being. Using data from a random web survey of college students across Texas, Park et al. (2009) find a positive relationship between intensity of Facebook use and students' life satisfaction. Drawing on the Luxemburgish part of the EVS 2008 section, Pénard et al. (2011) find evidence that non Internet users are less satisfied with their life than users. The correlation between Internet use and reported happiness is stronger for low income and young individuals. Suggestive hints about the role that SNSs may play in reducing inequalities in well-being are proposed by Steinfield et al. (2008). The authors find that life-satisfaction and self-esteem serve to moderate the relationship between Facebook usage intensity and bridging social capital: those with lower self-esteem and who are less satisfied with their life gained more from their use of Facebook in terms of bridging social capital than participants with higher self-esteem.
Overall, the main claim emerging from the empirical studies briefly outlined above is that online networking is a means for nurturing and articulating existing ties, as well as a fertile ground for activating latent ties and, less often, for creating new connections with strangers. In the next section, we will integrate the assumption that online networking may contribute to the building and preservation of social capital into a theoretical framework aimed at better understanding the causal nexus between computer-mediated communication, social participation, and the evolution of social capital.

3. Analytical framework

We consider an economy composed by a continuum (of measure 1) of identical individuals. In each instant of time *t*, a share $p \in (0,1)$ of the population is enjoying its leisure time, or, in other terms, is in the *L* mode. The remaining share of the population, $1-p$, is currently working, or is in the *W* mode. In each instant of time *t*, an individual has a *p* likelihood of being in the *L* mode and a $1-p$ likelihood of being in the *W* mode. In this paper we assume that: 1) leisure time is entirely devoted to social participation. 2) The allocation of time between leisure and work is exogenously given. These assumptions allow us to focus on the agents' choice of how to allocate their leisure time - which coincides with social participation - between face-to-face encounters and Internet-mediated interaction. As already outlined in the Introduction, participation through the Internet can take place in any spare moment - such as during a coffee break or before going to bed at night - and between people in distant locations - e.g. not in the same town. Internet-mediated interaction can be viewed as a defensive choice protecting the individual's relational life from the possible poverty of the social environment where she lives - which may not offer adequate opportunities to meet friends - and/or from the possibility that, at the given instant of time t, the individual's social contacts may all be in the *W* mode, thus unable to interact with her. Through the *SN* strategy, *L* mode and *W* mode individuals can interact with each other at different times. The possible asynchronism of interaction is indeed a distinctive feature that differentiates social participation through social networking sites from other technology-intensive communication tools, such as Skype and mobile phones.

In each instant of time t, individuals can thus choose to engage in two types of social participation: random pairwise face-to-face encounters, or Internet-mediated interaction. We model this choice by assuming that each agent can adopt one of the following two strategies: 1) the social networking (*SN*) strategy, within which social participation takes place both by means of online networking and face-to-face interaction. Individuals playing the *SN* strategy thus interact both through in-person random pairwise encounters and through the Internet. 2) The face-to-face (*FF*) strategy, which entails only in-person random pairwise encounters and does not encompass Internet-mediated interaction.

Let $x(t) \in [0,1]$ be the share of individuals adopting the *SN* strategy at the instant of time t. $1-x(t)$ is the share of the population adopting the alternative strategy *FF*.

One of the main features of social networks is that they allow the storage of past online interactions inside the network. In other words, the past evolution of x influences the network's wealth of ties. The higher the number of agents who chose to join the network in the past - i.e. the share $x(t)$ of the population currently playing the *SN* strategy - the more rewarding the choice to join the network will be. The growth of the quantity of agents playing *SN* will in fact entail an increase in the wealth of knowledge and information contained in online networks, and will contribute to the establishment of new online ties, probably directed at the strengthening and development of existing offline ties, as the literature suggests (Ellison et al. 2007; Steinfield et al. 2008; Pénard and Poussing 2010; Bauernschuster et al. 2011). In other words, an increase in the quantity of *SN*-type individuals is likely to imply an increase in the quality of online networks. From this point of view, the adoption of both strategies is path-dependent: the individual decision to develop her social interactions through the *SN* or the *FF* strategy is influenced by the number of individuals who chose the *SN* or the *FF* strategy in the past.

Let $K_N(t)$ be an index of quality of online networks. $K_N(t)$ can also be viewed as the stock of knowledge and information that has been added to online networks from time 0 to t. Every individual who joins online networks, i.e. who adopts the *SN* strategy, can enjoy the benefits of the stock $K_N(t)$. It is noteworthy that these benefits are extended to those individuals who, although being in the *L* mode, are matched with individuals who currently are in the *W* mode. The interaction between these individuals can in fact be asynchronous. By contrast, if two *FF*-playing individuals are randomly matched, they both need to be in the *L* mode to interact with each other. The stock $K_N(t)$ is a public good, in that it potentially benefits whoever connects to the Internet and adopts the *SN* strategy.

Assumption 1: We assume the payoff of the interaction through SNSs to be given by:

$$\alpha K_N(t)$$

where α is a strictly positive parameter. Since Internet-mediated interaction can also be asynchronous, this payoff is unrelated to the current behaviour of the individuals with whom players are matched, i.e. it does not depend on whether individuals are in the *W* or in the *L* mode, and on whether they play the *SN* or the *FF* strategy.

Assumption 2: We assume that the payoff of the random matching-interaction between individuals who simultaneously are in the *L* mode is as follows:

$$\begin{array}{cc} & \begin{array}{cc} SN & FF \end{array} \\ \begin{array}{c} SN \\ FF \end{array} & \begin{pmatrix} a & b \\ c & d \end{pmatrix} \end{array}$$

Where $a > b, \;\; d > c$, that is each player gets a higher payoff if she is matched with someone who adopts the same strategy.

Assumption 3: We normalize the payoff of individuals in the *W* mode, independently of the behaviour of those other individuals with whom they are randomly matched. We assume this payoff to be equal to 1.

Assumption 4: We assume that when individuals who are in the *L* mode are matched with individuals in the *W* mode, they receive a payoff equal to 0 if they are playing the *FF* strategy and equal to $\alpha K_N(t)$ if they adopt the *SN* strategy. If an individual adopts the *FF* strategy, she cannot interact with people who are in the *W* mode, since an in-person encounter is impossible. The adoption of the *SN* strategy, instead, allows the individual to benefit from the stock of latent interactions stored within online networks through asynchronous communication.

First, we compute the expected payoff of the *SN* strategy. In each instant of time *t*, i) a *SN* player has a $1-p$ likelihood of being in the *W* mode. Thus, her payoff has a $1-p$ likelihood of being equal to 1. ii) A *SN* player has a p likelihood of being in the *L* mode. Her payoff depends on the mode of the individual with whom she is randomly matched. If this individual is in the *W* mode, then the *SN* player's payoff is $\alpha K_N(t)$. Otherwise, the payoff also includes an additional reward depending on the strategy adopted by the other player, i.e. it is given by $\alpha K_N + ax + b(1-x)$, where x and $1-x$ are the likelihoods with which the *SN* and the *FF* strategy can respectively be adopted.

The expected payoff Π_{SN} of the *SN* strategy is thus given by:

$$\begin{aligned} \Pi_{SN}(K_N, x) &= 1 - p + p\{(1-p)\alpha K_N + p[\alpha K_N + ax + b(1-x)]\} = \\ &= 1 - p + p[\alpha K_N + pax + pb(1-x)] = \\ &= 1 - p + p[\alpha K_N + pb + p(a-b)x] \end{aligned}$$

In the same way, we can compute the payoff Π_{FF} of the *FF* strategy as:

$$\Pi_{FF}(K_N,x) = 1-p+p\{(1-p)\cdot 0 + p[cx+d(1-x)]\} =$$
$$= 1-p+p^2[d+(c-d)x]$$

The difference between the two payoffs is thus given by:

$$\Pi_{SN}(K_N,x) - \Pi_{FF}(K_N,x) = p[\alpha K_N + pb + p(a-b)x - pd - p(c-d)x] =$$
$$= p[\alpha K_N + p(b-d) + p(a+d-b-c)x]$$

Remark 1: $\Pi_{SN}(K_N,x)$ is increasing in x, i.e. the more the share x of the population participating in online networks grows, the higher the return of joining those networks will be.
Remark 2: $\Pi_{FF}(K_N,x)$ is decreasing in x, i.e. the payoff Π_{FF} decreases as the share of the population adopting the *SN* strategy grows.
Remark 3: The difference between the two payoffs, $\Pi_{SN}(K_N,x) - \Pi_{FF}(K_N,x)$, is an increasing function of x.
An increase in the share of the population adopting the *SN* strategy positively affects the payoff Π_{SN} and negatively affects the payoff Π_{FF}. In the case of Facebook, an increase in the number of subscribers will raise the individual's utility of joining the network. On the other hand, being outside of the network (i.e. continuing to play the *FF* strategy) may imply an increasing relational cost. Think for example of an *FF*-playing teenager whose classmates join Facebook. Not following them into the network may lead to the cooling of some relationships as well as to the exclusion from new ones established through the activation of latent ties. There is a self-feeding process making the relative performance of the *SN* strategy grow with the increase in the share x of the population adopting this strategy.
We assume that the time evolution of K_N depends on the share x of the population adopting the *SN* strategy, on the number of people who are in the *L* mode, and on a positive depreciation rate γ:

$$\dot{K}_N(t) = \beta p x(t) - \gamma K_N(t)$$

The depreciation rate $\gamma > 0$ of K_N is introduced to account for the cooling of online relationships related to the lack of care (social ties developed online need care to be preserved just as traditional ties do) and for the obsolescence of the stock of information deposited in online networks. $\beta > 0$ is a parameter measuring the elasticity of the time evolution of K_N to the share x of the population adopting the *SN* strategy.
Let us assume that the adoption process of the two strategies is given by the following replicator dynamics:

$$\dot{x} = x(1-x)[\Pi_{SN}(K_N,x) - \Pi_{FF}(K_N,x)] =$$
$$= px(1-x)[\alpha K_N + p(b-d) + p(a+d-b-c)x]$$

Combining the two equations above we have the following system:

$$\dot{K}_N = \beta p x - \gamma K_N$$

$$\dot{x} = px(1-x)\left[\alpha K_N + p(b-d) + p(a+d-b-c)x\right]$$

which describes the time evolution of the share of the population interacting through online networks and of the wealth of ties and information contained in online networks.

4. Results

Along the line Γ_1**:**

$$x = \frac{\gamma}{p\beta} K_N$$

we have $\dot{K}_N = 0$. Γ_1 separates the left side of the plane (K_N, x), where $\dot{K}_N > 0$, from the right side, where $\dot{K}_N < 0$ holds.

It holds $\dot{x} = 0$ for $x = 0,1$ and along the line Γ_2:

$$x = \frac{d-b}{a+d-b-c} - \frac{\alpha}{p(a+d-b-c)} K_N$$

On the left side of Γ_2 it holds $\dot{x} < 0$ and on the right side of Γ_2 it holds $\dot{x} > 0$. The slope of Γ_2 is strictly negative.
It is easy to check the following results. The system admits at most three stationary states:

$$K_N = 0,\ x = 0$$

$$K_N = \frac{p\beta}{\gamma},\ x = 1$$

$$\overline{K}_N = \frac{p\beta(d-b)}{(a+d-b-c)\gamma + \alpha\beta},\ \overline{x} = \frac{\gamma(d-b)}{(a+d-b-c)\gamma + \alpha\beta}$$

The third stationary state, when it does exist, is always a saddle point. The state $(K_N, x) = (0,0)$ is locally attractive if:

$$b - d < 0$$

and it is a saddle point if the condition $b - d \geq 0$ holds.
The state $(K_N, x) = (\frac{p\beta}{\gamma}, 1)$ is locally attractive if:

$$\alpha\frac{\beta}{\gamma} + a - c > 0$$

and it is a saddle point if the condition $\alpha\frac{\beta}{\gamma} + a - c \leq 0$ holds. If it is beneficial for SN players to change their strategy when they are matched with individuals of the other type, then a stationary state where all interactions are developed only by means of face-to-face encounters - and no interaction takes place through online networking - is locally attractive. If *SN* players always get a higher payoff when they are matched with *FF* players, then the state where $K_N = 0$ and $x = 0$ is not attractive.

A stationary state where all individuals develop their social relationships both through in-person encounters and participation in online networks is more likely when: i) the payoff that *SN* players receive when they are randomly matched with individuals of the same type is high. ii) The payoff received by *FF* players who are randomly matched with *SN* players is low. iii) The elasticity of the time evolution of the stock K_N to the share x of the population adopting the *SN* strategy is high. iv) The depreciation rate γ is low. v) The elasticity of the payoff of Internet-mediated interaction to the stock K_N is high.

The above basic results allow us to give a complete classification of replicator dynamics:

Case I: $b - d \geq 0$. In this context, the *SN* strategy always dominates *FF* for every values of x and K_N. It holds $\dot{x} > 0$ for every $x \in (0,1)$ and the system converges to the stationary state $(K_N, x) = (\frac{p\beta}{\gamma}, 1)$ (see Figure 1), where the wealth of information and ties of online networks reaches its highest possible level and everyone adopts the *SN* strategy, whatever the initial values of K_N and x are.

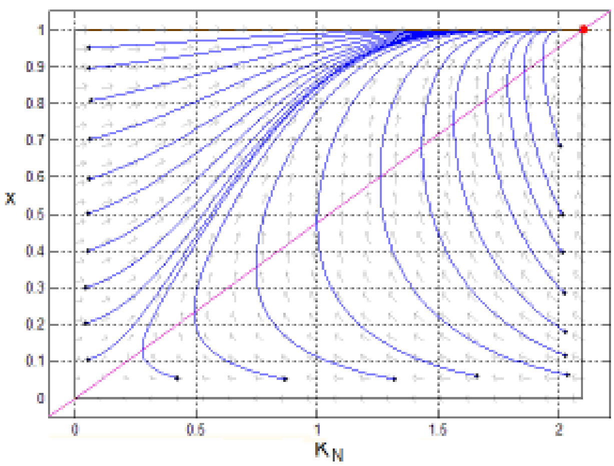

Figure 1

Case II: $\alpha \frac{\beta}{\gamma} + a - c \leq 0$. In this context, the *FF* strategy dominates the *SN* mode of participation. It holds $\dot{x} < 0$ for every $x \in (0,1)$ and the system converges to the stationary state $(K_N, x) = (0,0)$, where online networking disappears and everyone plays the *FF* strategy whatever the initial values of K_N and x are (see Figure 2).

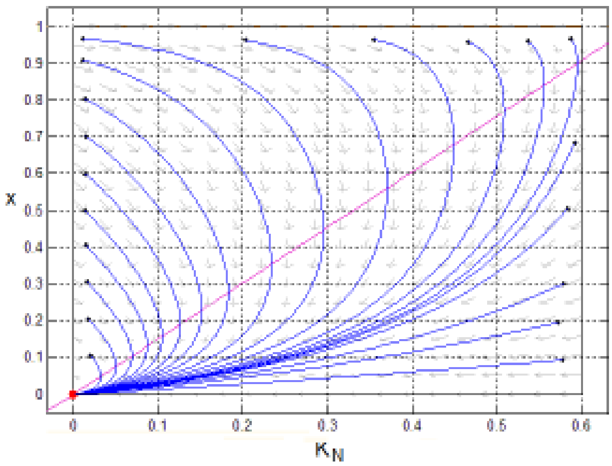

Figure 2

Case III: $b-d<0$ and $\alpha\frac{\beta}{\gamma}+a-c>0$. If both the conditions in Cases I and II are not satisfied, then a bi-stable dynamic regime occurs where both the stationary states $(K_N, x)=(0,0)$ and $(K_N, x)=(\frac{p\beta}{\gamma},1)$ are locally attractive and the interior steady state $(\overline{K}_N,\overline{x})$ is a saddle point. The stable manifold of the stationary state separates the basins of attraction of the two attractive states $(K_N, x)=(0,0)$ and $(K_N, x)=(\frac{p\beta}{\gamma},1)$ (see Figure 3).

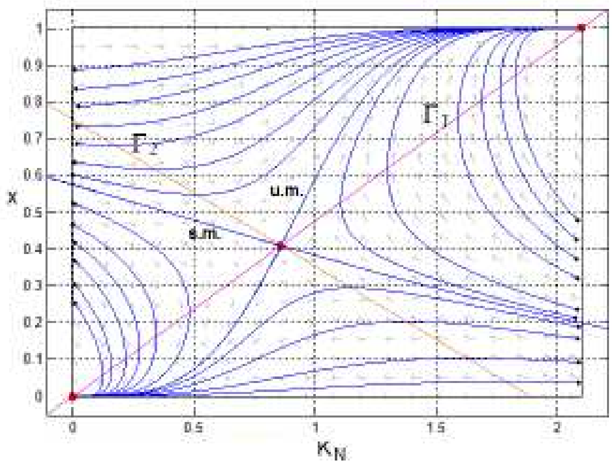

Figure 3

The basins of attraction of the stationary state $(\frac{p\beta}{\gamma},1)$, where all agents chose the *SN* strategy and the stock K_N representing the wealth of knowledge and ties of the Internet reaches its highest level, expands as the time *p* available for social participation decreases. Internet-mediated interaction can be seen as a tool allowing individuals to manage their social relationships despite increasing time pressures and possible distance constraints.

5. Welfare analysis

Let us now consider the welfare properties of the two attractive stationary states $(K_N, x) = (0,0)$ and $(K_N, x) = (\frac{p\beta}{\gamma},1)$. Starting from the payoffs:

$$\Pi_{SN}(K_N, x) = 1 - p + p[\alpha K_N + pb + p(a-b)x]$$
$$\Pi_{FF}(K_N, x) = 1 - p + p^2[d + (c-d)x]$$

we see that, at the stationary state $(K_N, x) = (0,0)$, every individual gets the payoff:

$$\Pi_{FF}(0,0) = 1 - p + dp^2$$

while, at the stationary state $(K_N, x) = (\frac{p\beta}{\gamma},1)$, every individual gets the payoff:

$$\Pi_{SN}(\frac{p\beta}{\gamma},1) = 1 - p + p\left[\alpha\frac{p\beta}{\gamma} + pb + p(a-b)\right]$$

The payoff associated with the stationary state $(K_N, x) = (0,0)$ where all agents adopt the *FF* strategy is higher than that associated with the stationary state $(K_N, x) = (\frac{p\beta}{\gamma},1)$ where everyone adopts the *SN* strategy, that is:

$$\Pi_{FF}(0,0) > \Pi_{SN}(\frac{p\beta}{\gamma},1)$$

if and only if:

$$d > \alpha\frac{\beta}{\gamma} + a$$

Notice that the condition (3) does not depend on the attractivity conditions (1) and (2) of the two stationary states $(K_N, x) = (0,0)$ and $(K_N, x) = (\frac{p\beta}{\gamma},1)$. Consequently, depending on the value of parameters, the stationary states where no one socially participates through online networking may dominate the state where everyone adopts the *SN* strategy, or vice versa. As in Antoci et al. (2011a), our model does not provide clear-cut welfare implications, and both the stationary states can be socially suboptimal destinations for the economy.

6. Conclusions

This paper develops an evolutionary framework to analyze how social relations may evolve as a consequence of Internet-mediated interaction and of the increasing pressure on the time available for social interaction. We assume that individuals can interact with each other through random pairwise face-to-face encounters and by connecting with their social contacts through online networks. Agents can chose between two possible strategies of social interactions: a face-to-face (*FF*) strategy, which is entirely developed through in-person encounters and entails no Internet-mediated interaction, and a social networking (*SN*) strategy, through which individuals maintain their interpersonal relationships in a mixed way, encompassing both physical encounters and involvement in online networks.

Our findings suggest that the explosion of social networking is likely to lead a growing share of the population to embrace the *SN* strategy, especially in an scenario characterized by a increasing pressure on time. The process is path dependent: the increase in the share of the population adopting the *SN* strategy strengthens the wealth of knowledge, information and ties contained in online networks, making them more and more attractive for possible newcomers. The analysis of the model shows that, when physical interactions take place as random pairwise encounters, the economy may converge to a stationary state where all agents nurture social relations both through face-to-face interactions and online networking. Although our results suggest this is the more likely scenario, the welfare analysis does not allow us to discuss the social desirability of this evolution. Both the stationary state where all people chose to interact via a mix of in- person encounters and online networking ($x = 1$) and the other where all interactions are developed through physical encounters ($x = 0$) can in fact be socially suboptimal destinations for the economy. However, the finding that the basins of attraction of the stationary where $x = 1$ expands as the time p available for social participation decreases suggests that Internet-mediated interaction is also used as a defensive tool allowing individuals to take care of their social relationships despite time and distance constraints. It thus seems reasonable to argue that Internet use can support well-being by counterbalancing some detrimental effects of the increasing pressure on time. From the policy point of view, this implies that the reduction in the digital divide could be an effective measure to contain inequalities in the distribution of well-being.

This paper represents the last step in a research programme aimed at analyzing the evolution of social participation and the accumulation of social capital in relation to economic growth and technological progress. In previous works, we highlighted how the reduction in the time p available for social participation can trigger self-feeding processes leading to the progressive erosion of the stock of social capital (Antoci et al. 2011b; 2011c). In these papers, we analyzed a scenario in which the time for social participation is an endogenous variable (i.e. it depends on agents' allocation choices) and social relationships can be developed only by means of face-to-face interaction. In the present work, we address a scenario in which agents can interact with each other both through actual encounters and online networking, but p is exogenously given. The analysis suggests that, under certain conditions, the stock of information, knowledge, and social ties accumulated within online networks can create an infrastructure which helps individuals to develop their social participation despite space and time constraints. More specifically, the asynchronism that is a feature of online interactions can play an important role in reconciling working activities and pervasive busyness with the need to manage human relationships. Even if this result may look predictable, we are persuaded that this paper makes a contribution to the literature by being the first to provide a theoretical framework for analyzing the interdependence between increasing busyness, social participation and phenomena such as online networking and, in general, Internet-mediated communication, which are literally revolutionizing our lives. A straightforward implication for further researches is the need to analyze the agents' choice between the two possible strategies of social interaction within a framework where the time p for social participation is endogenously given.

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