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See you on Facebook! A framework for analyzing the role of computer-mediated interaction in the evolution of social capital☆

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A B S T R A C T

Empirical studies have documented a decline in indicators of social participation in the last five decades. The responsibility of social disengagement has often been attributed to pervasive busyness and the increasing pressure on time. In this paper we argue that computer-mediated interaction, and particularly online networking, can help mitigate this downward trend. We develop a logical framework for assessing the role of the Internet in the evolution of social participation. We analyze an economy where agents can develop their social interactions through two main modes of participation, one encompassing both online networking and face to face interactions, and the other solely based on physical encounters. We study the interdependence between the increase in the pressure on time and the variation in the relative performance of the two strategies of participation.

1. Introduction

Many empirical studies document that a decline in indicators of social participation has occurred in the last five decades (Paxton, 1999; Putnam, 2000; Robinson and Jackson, 2001; Costa and Kahn, 2003; Bartolini et al., 2011).[1] The most obvious cause of the tendency to reduce relational activities and drop out of community affairs is pervasive busyness. As Putnam (2000) writes in *Bowling Alone*, a lack of time is in fact the most common explanation that Americans offer for social disengagement when interviewed in survey studies. Putnam suggests that endemic economic pressures, job insecurity, and declining real wages, especially among the lower two-thirds of the income distribution, may all be potential causes of disengagement (2000, p. 189).

Previous theoretical analyses of the evolution of social capital (Antoci et al., 2011a,b) have shown that aggregate social participation is strongly path-dependent, pointing out the possibility of a self-feeding cycle further accelerating the disengagement process.[2] As the social environment deteriorates, relational activities can become less and less rewarding. Agents may thus prefer to reduce their own social participation as well (Antoci et al., 2007, 2011a).

In this paper we argue that computer-mediated interaction, and particularly online networking, can help mitigate this downward trend. Even though, with respect to face-to-face interactions, online networking presents a number of easily guessable shortcomings, it certainly exhibits two major advantages: it is both less time intensive and less expensive.

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[1] The debate was raised by Putnam (1995) who found a significant decline in Americans' engagement in social and political activities starting from the 1970s. The robustness of this claim to the use of different indicators has since been tested by a number of subsequent studies. The overall findings of this literature seem to support the thesis that social capital has declined in the U.S., although not so dramatically as Putnam claimed.

[2] This finding is consistent with empirical analyses of historical trends (see for example Putnam et al., 1993; De Blasio and Nuzzo, 2010).

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There are at least three reasons to suspect that web-mediated social participation can work as an effective strategy to protect the relational sphere of individuals' lives from the pressure of time. First, it is less exposed to the deterioration of the social environment that physically surrounds individuals. Online networking allows people to interact with friends and acquaintances even in distant locations. Second, it is less time consuming than face-to-face interaction. So, it suffers less from the reduction in the time available for social participation. Social networking sites like Facebook and Twitter allow users to stay in touch with friends in their spare time, while sitting at a desk during their working day or while waiting for the train. Third, online interactions contribute to the accumulation of an "Internet social capital" which benefits solely Internet users. A peculiarity of this kind of social capital is that it allows asynchronous social interactions: one can benefit from another's participation, for example through the act of reading a message or viewing a photo, even if the person who wrote the message or posted the photo is currently offline.

In our view, social participation through the Internet can be considered as a "defensive choice" allowing people to protect their relations from the rising pressure on time and from the possible decrease in opportunities for physical encounters. The spreading 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. (2011c), it may prevent the economy from falling into a "social poverty trap".

In this paper we develop a theoretical framework for assessing the potential role of Internet-mediated interaction in halting the self-feeding process of declining participation. To this purpose, we analyze an economy where agents can develop their social participation in two main modes: they can adopt a "social networking strategy", allowing them to participate both through online networking and face-to-face interaction. Or they can opt for a "face-to-face strategy", which does not encompass Internet-mediated interaction. In this case, all relationships take place through face-to-face encounters.

Our main objective is to point out the possible interdependence between the rise in pressure on time and the variation in the relative performance of the two strategies of participation. This operation is intended to provide theoretical research, as well as the rapidly growing empirical literature on the role of the Internet, with a logical framework for analyzing the causal nexus possibly connecting phenomena such as online networking, other forms of web-mediated communication, the evolution of human interaction, and the accumulation of social capital.

The remainder of the paper is organized as follows: in the next section we review the related literature. In Section 3 we present our framework. In light of this framework, Section 4 discusses the interdependence between the phenomena we are considering. The paper finishes with a few concluding remarks and considerations for further studies.

2. Related literature

For almost a decade, studies on social networking sites (SNSs) have been carried out in the fields of law and applied psychology, mainly pointing at issues like privacy risks and the effects of the Internet on teenagers' mental health. Early studies in the field of sociology mostly shared the fear that the Internet would cause a progressive reduction in social interaction. This concern was based on three main arguments. First, the more time people spend using the Internet during leisure time, the more time has to be detracted from social activities like communicating with friends, neighbours and family members (Nie, 2001; Nie et al., 2002; Gershuny, 2003; Wellman et al., 2001). These studies date back to shortly before the explosion of online networking, and they could not differentiate between pure entertainment and social activities. 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 SNSs, which in turn brings about engagement in social activities. According to data on the U.S. provided by the Pew Internet & American Life Project, as of September 2009 nearly three quarters (73%) of online teens (aged 12–17) and an equal number (72%) of young adults (18–29) use social network sites. This evolution makes any comparison between the Internet and TV anachronistic.

Second, the Internet allows users to conduct many daily transactions such as shopping or banking online from home (Nie et al., 2002; Franzen, 2003). Supporters of this argument suggest that to shop and carry out a number of tasks without leaving home may reduce face-to-face interaction. A straightforward objection is that transactions and other commissions often do not have particular relational implications. In fact, they divert time from relational activities. If we spend part of the day dealing with a bank or a public administration office, then we may be constrained to work more to make up for the hours lost, and to give up the intention of meeting friends. Obtaining a birth certificate or a bank statement online in just a few seconds from home allows us to gain more time for leisure and social participation.

A third more intriguing argument relies on the concept of "community without propinquity" (Webber, 1963) and on the earlier theories of the Chicago School of Sociology. In a famous paper, Wirth (1938) claimed that a heterogeneous urban environment would be characteristic of the absence of "intimate personal acquaintanceship" and would result in the "segmentation of human relations" into those that were "largely anonymous, superficial, and transitory" (Wirth, 1938, p. 1). This argument can be easily applied to the Internet, which seems to have the potential to fragment local communities into new virtual realities of shared interest that may negate the necessity of face-to-face encounters. The "anonymization hypothesis", however, has been challenged by results from studies specifically targeted at verifying the effects of online networking on communities living in a precise geographic location (e.g. a city area or suburb). The seminal paper in this field is probably the pioneer study by Hampton and Wellman (2003). Drawing on survey and ethnographic data from a "wired suburb" of Toronto, the authors find that high-speed, always-on access to the Internet, coupled with a local online discussion group, transforms and enhances neighbouring. The Internet particularly supports increased contacts with weaker ties, without bringing about a deterioration of 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). A similar study by Kavanaugh et al. (2005) on the Blacksburg Electronic Village concludes that computer-mediated interactions have positive effects on community interaction, involvement, and social capital.

Findings from the latest wave of studies (i.e. carried out between 2006 and 2010) on the relational effects of social networking unanimously converge on the claim that online networks support the consolidation and development of existing ties.

These works appear to be more reliable than those arguing for a possibly negative relationship between web-mediated interaction and social capital because they were conducted *after* the explosion of online networking. Thus, they specifically aim to assess the implications of SNSs.

According to this strand of the literature, SNSs support the strengthening of bonding and bridging social capital (Valkenburg et al., 2006; Ellison et al., 2007; Steinfield et al., 2008; Gilbert and Karahalios, 2009; Burke et al., 2009), allow the crystallization of weak or latent ties that might otherwise remain ephemeral (Haythornthwaite, 2005; Ellison et al., 2007), support teenagers' self-esteem – encouraging them to relate to their peers (Ellison et al., 2007; Steinfield et al., 2008), stimulate social learning (Burke et al., 2010), enhance social trust, civic participation and political engagement (Park et al., 2009), facilitate the creation of electronic networks of practice (Wasko and Faray, 2009; Landqvist and Teigland, 2005; Matzat, 2010), and help the promotion of collective actions to the pursuit of shared goals (Landqvist and Teigland, 2005).

Drawing on survey data from a random sample of 800 Michigan State University undergraduate students, Ellison et al. (2007) find that certain kinds of Facebook use can help students accumulate and maintain bridging social capital. The authors suspect that the social network serves to lower the barriers to participation so that students 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). As argued by Haythornthwaite (2005), 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). 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". Ellison et al. (2007) also demonstrate a correlation between bridging social capital and subjective well-being measures: less intense Facebook users report lower levels of life-satisfaction, self-esteem and bridging social capital. As an explanation, the authors suggest that Facebook use may be helping to overcome barriers faced by students who have low satisfaction and low self-esteem.

Steinfield et al. (2008) analyzed panel data from two surveys on Facebook users conducted a year apart at a large U.S. university. The authors claim that SNSs may be particularly helpful in assisting students during the transition from school to college or work. In most cases, these transitions bring about socially disruptive changes in individuals' lives.

Taking into account the results from the latest studies on Facebook users, it is possible to argue that SNSs can work as an antidote, slowing the mobility-driven process of social capital's erosion. Online networking indeed seems to support the maintenance of relationships among individuals entering college, moving between residences, graduating and entering the professional workforce (Steinfield et al., 2008).

Using data from a random web survey of 2603 college students in Texas, Valenzuela et al. (2008) find moderate, positive relationships between intensity of Facebook use and students' life satisfaction, social trust, civic participation and political engagement. After controlling for a series of variables, the authors claim that their results show that the association between online networking and social capital cannot be considered spurious. Despite the interesting results and convincing interpretations, the empirical analyses carried out by Ellison et al. (2007), Steinfield et al. (2008), and Valenzuela et al. (2008) share a common shortcoming: they all refer to localized communities, such as the students of a specific college. An interesting development in this sense is provided by two recent studies based on the matching of survey and server log data provided by Facebook (Burke et al., 2009, 2010). The cooperation with the biggest social network has allowed researchers to investigate the behaviour of larger and more representative samples.

Drawing on survey data from a sample of 1193 participants recruited via an "ad" on Facebook targeted at English-speaking adults, Burke et al. (2009) find that overall SNS activity, particularly friend count, is positively correlated with bonding and bridging social capital. It is also negatively correlated with loneliness. Content production (e.g. writing notes and sharing photos) is strongly associated with increases in bridging social capital. Using server log data from approximately 140,000 newcomers who joined Facebook in March 2008, Burke et al. (2010) find evidence of social learning: newcomers who see their friends contributing go on to share more content themselves.

Overall, the main claim emerging from the empirical studies presented in the review is that online networking is a means for nurturing and articulating existing ties, as well as a fertile ground for the development of new ones. We try to integrate this hypothesis into a logical framework aimed at the assessment of the causal relationships possibly existing between online networking, social interaction, and the evolution of social capital.

3. A simple framework to analyze the role of web-mediated interaction

We start from the acknowledgement that a share of the population develops its social life both through face-to-face encounters and online contacts via SNSs such as Facebook. Drawing on a review of descriptive data from the major U.S. survey source (e.g. the Pew Internet & American Life Project), we assume that a significant part of the population remains unfamiliar with online networking. These individuals are likely to develop their social participation only by meeting their friends and acquaintances in person.

We model an economy composed of a continuum (of measure 1) of identical individuals. In each instant of time they decide how to allocate their leisure time, p, which is exogenously given, choosing between two kinds of social interaction.

In each instant of time t, the share $x(t) \in [0, 1]$ of agents embraces a social networking strategy SN, i.e. their social participation relies both on online networks and face-to-face interaction. The remaining share of the population $1 - x(t)$ adopts a face-to-face strategy FF: they do not interact online and thus develop all their relationships through face-to-face encounters.

We assume that the technology for social networking is available for all agents. In principle, individuals can thus simultaneously interact with multiple agents (theoretically, even with all of the agents in the population).

The payoff of the FF strategy, Π^{FF}, depends on $x(t)$ and on the share of time devoted to social interaction, p, $\Pi^{FF} = \Pi^{FF}(x, p)$. The payoff of the SN strategy, Π^{SN}, depends on the share of the population adopting it, $x(t)$, on the time agents devote to social participation, p, and on the wealth of ties – or, in other words, the stock of social capital – of online networks at time t, $K_N(T)$: $\Pi^{SN} := \Pi^{SN}(K_N, x, p)$.

In this framework, we focus solely on the social capital of the Internet, instead of also accounting for the stock of ties accumulated through face-to-face interactions. This strong assumption is made for the sake of simplification and is motivated by two main reasons. First, there is a significant difference in the velocity of accumulation of the two types of stock. Online ties can be formed and deepened much more rapidly than face-to-face interactions. Second, given the extraordinary velocity with which the social networking revolution is taking off, our model is intended to address a rather limited period of time.

The stock $K_N(t)$ is a public good, in that it potentially benefits whoever is connected to the Web and adopts the SN strategy. A peculiarity of K_N is that it allows asynchronous interactions which may help people to reconcile working activities and pervasive busyness with the need to take care of social relationships. When individuals cannot meet in person, nor chat at distance due to time differences (think, for example, of people working on a night shift, or of friends living in different hemispheres), the social capital of the Internet offers the possibility of a quality though deferred interaction. A worker on a night shift can deposit on the Web his interaction with others (e.g. by sending emails, writing a post on his blog, sharing photos or comments on Facebook): his friends will "complete" the interaction by watching the deposited material and eventually sending feedback when they awake or when they find the time, thereby contributing to the accumulation of the Internet social capital. What happens here is not the replacement of actual encounters with deferred, more impersonal and less deep, contacts. Rather, in this case the social capital of the Internet offers individuals the opportunity to preserve relationships which would otherwise be unravelled by busyness, distance, and the pressure of time.

We assume that the payoff Π^{FF} decreases as the share of the population adopting the *SN* strategy grows. On the other hand, we account for the claim that online networks are used mainly to maintain existing offline relationships (Boyd and Ellison, 2007), to crystallize weak ties (Ellison et al., 2007) and to activate latent ties (Haythornthwaite, 2005), through the assumption that the payoff Π^{SN} increases as K_N, i.e. the stock of the social capital of the Internet, grows. In other words, the more the number of relatives and friends who join SNSs grows, the higher the return of joining those networks will be as well. Formally, we assume $\Pi^{SN}(K_N, x, p)$ and $\Pi^{FF}(x, p)$ to be differentiable functions satisfying the following conditions:

$$\frac{\partial \Pi^{SN}(K_N, x, p)}{\partial x} > 0 > \frac{\partial \Pi^{FF}(x, p)}{\partial x}$$

$$\frac{\partial \Pi^{SN}(K_N, x, p)}{\partial K_N} > 0$$

An increase in the share x of the population adopting the *SN* strategy positively affects the payoff Π^{SN} and negatively affects the payoff Π^{FF}: the more of our friends that join Facebook, the higher the utility of subscribing to the platform will be as well. 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.

Since the comparative advantage of the *SN* strategy is partly driven by the pressure on time, we assume that, when the time p available for social participation grows, the payoff Π^{FF} for agents playing the *FF* strategy increases more than the payoff Π^{SN} obtained by *SN* players. If agents are forced to be deeply immersed in their professional activities, the ability to take care of human relationships in spare moments (e.g. while on the train, or at home before going to sleep) becomes a precious means for the preservation of social life. *SN* can thus also be interpreted as a "defensive" strategy that individuals adopt to protect their social life from the growing pressure on time. The more the time available for social participation p declines, the more a defensive reaction is needed, making the *SN* strategy comparatively more profitable. By contrast, if the time p for leisure grows, then there is a relaxation in the need for defensive behaviours, which makes the *FF* strategy comparatively more profitable. Formally, this assumption can be expressed as follows:

$$\frac{\partial \Pi^{FF}(x, p)}{\partial p} > \frac{\partial \Pi^{SN}(K_N, x, p)}{\partial p} \tag{1}$$

We follow an evolutionary game approach and assume that the time derivative of $x(t)$, $x = dx/dt$, is given by:

$$\dot{x} = F[x, \Pi^{SN}(K_N, x, p) - \Pi^{FF}(x, p)]$$

where F is a differentiable function for every $x \in (0, 1)$ and $K_N, p \geq 0$. Furthermore, F satisfies the following assumptions:

(a) It is strictly increasing in $\Pi^{SN} - \Pi^{FF}$ (i.e. $F_2 > 0$) for every $x \in (0, 1)$ ("payoff monotonicity" assumption, see for example Weibull, 1995);
(b) $F(x,0) = 0$ for every $x(t) \in [0, 1]$, i.e. x does not change when the payoffs of the two strategies are the same.
(c) Moreover, as usual, we assume that the share $x(t)$ of agents adopting the *SN* strategy cannot become negative or larger than 1 (i.e. $0 \leq x(t) \leq 1$ always holds); in particular, we assume that F satisfies the following conditions:

$$\begin{aligned} &F[0, \Pi^{SN}(K_N, 0, p) - \Pi^{FF}(0, p)] = 0 \quad \text{if} \quad \Pi^{SN}(K_N, 0, p) - \Pi^{FF}(0, p) \leq 0 \\ &F[0, \Pi^{SN}(K_N, 0, p) - \Pi^{FF}(0, p)] > 0 \quad \text{if} \quad \Pi^{SN}(K_N, 0, p) - \Pi^{FF}(0, p) > 0 \end{aligned} \tag{2}$$

and

$$\begin{aligned} &F[1, \Pi^{SN}(K_N, 1, p) - \Pi^{FF}(1, p)] = 0 \quad \text{if} \quad \Pi^{SN}(K_N, 1, p) - \Pi^{FF}(1, p) \leq 0 \\ &F[1, \Pi^{SN}(K_N, 1, p) - \Pi^{FF}(1, p)] > 0 \quad \text{if} \quad \Pi^{SN}(K_N, 1, p) - \Pi^{FF}(1, p) < 0 \end{aligned} \tag{3}$$

The time evolution of the Internet's stock of social capital is path dependent and positively influenced by the size x of the population adopting the *SN* strategy. An increase in the wealth of ties of online networks at time t will foster the accumulation of social capital K_N. Furthermore, since human relations developed online need care to be preserved just like "traditional" ties, we introduce a positive social capital depreciation rate to account for possible cooling over time.

The time evolution of K_N is thus described by the equation:

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

where β is the elasticity of the time evolution of K_N with respect to the share x of the population adopting the *SN* strategy and γ is the depreciation rate of K_N.

Notice that the maximum sustainable level of the stock K_N is $K_N = (\beta/\gamma)$, which can be reached only if the whole population chooses the *SN* strategy (i.e. $x = 1$). We assume that, in this context ($x = 1$ and $K_N = (\beta/\gamma)$), the payoff Π^{SN} is higher than the payoff Π^{FF}. On the other hand, if every individual adopts the *FF* strategy (i.e. $x = 0$) and $K_N = 0$, the payoff of *SN* is lower than that of *FF* (whatever the value of p is):

$$\Pi^{SN}\left(\frac{\beta}{\gamma}, 1, p\right) > \Pi^{FF}(1, p) \tag{4}$$

$$\Pi^{SN}(0, 0, p) < \Pi^{FF}(0, p) \tag{5}$$

Thus, the system to be analyzed is:

$$\dot{K}_N = \beta x - \gamma K_N \tag{6}$$

$$\dot{x} = F[x, \Pi^{SN}(K_N, x, p) - \Pi^{FF}(x, p)] \tag{7}$$

which is defined in the set:

$$S := \{(K_N, x) \in R^2 | K_N \geq 0, \quad 1 \geq x \geq 0\}$$

4. The two modes of social participation and the accumulation of social capital

The following propositions highlight the qualitative features of the dynamics of the framework.

Proposition 1. *The dynamic system (6) and (7) always admits three stationary states, i.e. three states (K_N,x) where $\dot{K}_N = \dot{x} = 0$ (see Fig. 1):*

$$(K_N, x) = (0, 0), \left(\frac{\beta}{\gamma}, 1\right), (K_N^*, x^*)$$

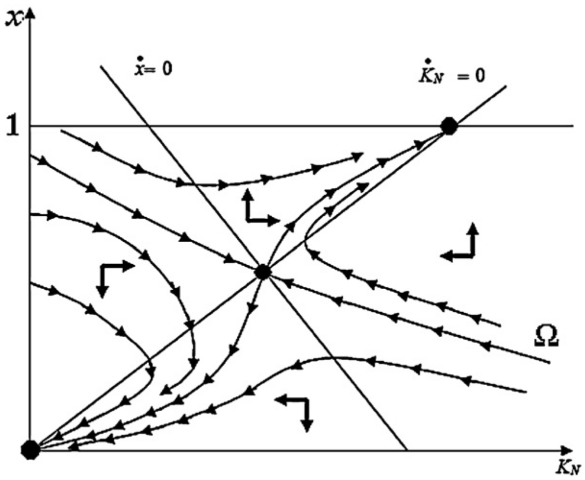

Fig. 1. Phase plane of the dynamic system (6) and (7).

where $(\beta/\gamma) > K_N^* > 0$ *and* $1 > x^* > 0$.

Proof of Proposition 1 is presented in Appendix.

Proposition 2. *The interior stationary state* (K_N^*, x^*) *is always a saddle point, while both the stationary states* $(\beta/\gamma, 1)$ *and (0,0) are locally attractive. Each trajectory of the dynamic system (6) and (7) approaches one of these stationary states (see Fig. 1).*

Proof of Proposition 2 is presented in Appendix.

Notice that in Fig. 1 the basins of attraction of the stationary states (0,0) and $(\beta/\gamma, 1)$ are separated by the stable manifold Ω of the stationary state (K_N^*, x^*), which is a saddle point. The next proposition shows how a variation in the parameter p affects the size of such basins.

Proposition 3. *The size of the basin of attraction of the stationary state* $(\beta/\gamma, 1)$ *increases if the value of the parameter p decreases (see Fig. 2).*

Proof of Proposition 3 is presented in Appendix.

The same shift in the position of Ω can be caused by an increase in the elasticity β of the accumulation of social capital with respect to the share x of agents playing *SN*, or by a reduction in the depreciation rate γ of K_N. Both these parameters mainly depend on a variety of (mainly technological) factors. First, the design and dimension of the prevalent online networks are likely to play a relevant role.

At the dawn of the social networking era, the elasticity β probably had a "low" value. At that time, the social capital of the Web was "fragmented" into a large number of small networks, within which there was a limited probability of newcomers meeting all of their *SN*-playing current friends. On the other side, people who joined just one network were not necessarily able to connect with members of other platforms.

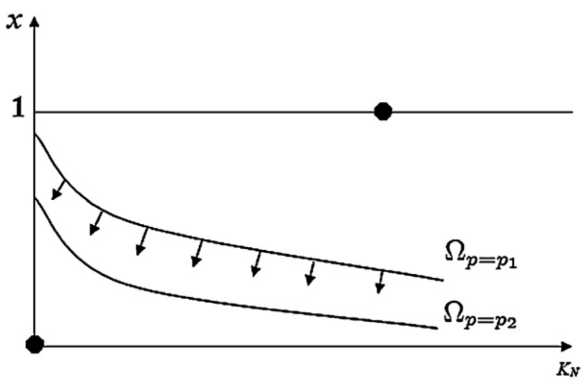

Fig. 2. Shift of the stable manifold Ω when p varies from $p = p_1$ to $p = p_2 < p_1$.

If newcomers do not connect with each other, then the increase in their number is likely to exert a limited influence on the overall wealth of ties of the Web. This implies a low value of the elasticity β. By contrast, if newcomers are attracted by a small number of "big" networks, or even by just one enormous platform like Facebook, they are more likely to interact with each other and to reconnect with a major share of their current, old-*SN*-player friends. An increase in the share x of the population adopting the *SN* strategy will thus exert a major influence on the Web's social capital, i.e. the elasticity β has a "high" value.

In this framework, the "explosion" in the number of subscribers that Facebook and a few other sites have experienced in the last two years can be viewed as a true turning point. Before the Facebook era, a newcomer could choose among at least 100 major online networks with approximately 100,000 subscribers. The risk of meeting just a very limited part of one's circle of friends on the Web was very high, so that the Web could hardly be seen as an effective, alternative, way to take care of the relational sphere of an individual's life. Now that Facebook has more than 500 million users, the probability of finding a large and growing part of one's actual network of relations on the platform is higher. Newcomers will be attracted by just one or two major sites (probably Facebook and Twitter) where they will be able to find their old friends and make a significant number of new ones. So, the stock of the Web's social capital will benefit from an increase in the share x of *SN* players to a higher extent.

Second, since the dimension of the network determines its gravitational pull, larger networks are likely to keep their members for a longer time. Relationships nurtured through such networks are thus less likely to cool over time, and the depreciation rate γ probably exhibits a lower value. Everyday Facebook experience indeed suggests that users who temporarily move away from the platform are very likely to come back. Upon their return, they will find the network as they left it, making it easy to engage in the same old relationships again. Another technological factor that may decisively affect the social capital of the Web is the diffusion of broadband. Online networks can attract new users only as far as people can be easily connected to the Web. The lack of proper infrastructure can thus be viewed as a factor reducing both the payoff of *SN* players and the elasticity β.

5. Welfare analysis

Let us now consider the welfare properties of the two attracting stationary states $(K_N, x) = (0, 0)$ and $(K_N, x) = (\beta/\gamma, 1)$. Fig. 3 shows the payoff $\Pi^{FF}(x, p)$ and the payoff $\Pi^{SN}(K_N, x, p)$; the latter evaluated at $K_N = (\beta/\gamma)$. Notice that two cases are possible: (0,0) may Pareto dominate $(\beta/\gamma, 1)$ (Fig. 3a) or vice versa (Fig. 3b). In particular, (0,0) Pareto dominates $(\beta/\gamma, 1)$ if $\Pi^{SN}(\beta/\gamma, 1, p) < \Pi^{FF}(0, p)$ while the opposite holds if $\Pi^{SN}(\beta/\gamma, 1, p) < \Pi^{FF}(0, p)$. Both these scenarios are consistent with conditions (4) and (5). As expected, our model does not provide clear-cut welfare implications, both $(\beta/\gamma, 1)$ and (0,0) can be socially suboptimal destinations for the economy, depending on the payoff structure; therefore, both $(\beta/\gamma, 1)$ and (0,0) can become "social poverty traps".

6. Concluding remarks

This paper develops an evolutionary framework to explore the dynamics of social interaction in an environment where social relationships can be developed in two possible ways: through face-to-face encounters (the *FF* strategy), or by means of a mix of actual meetings and online interactions (*SN* strategy). Our findings

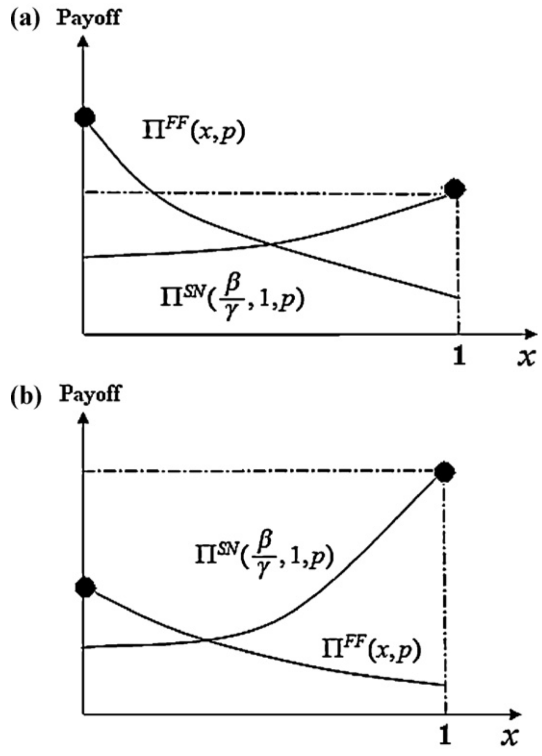

Fig. 3. (a) Stationary state (0,0) Pareto dominates $(\beta/\gamma, 1)$. (b) Stationary state $(\beta/\gamma, 1)$ Pareto dominates (0,0).

suggest that the new opportunities for participation offered by social networking may progressively lead a growing share x of the population to embrace the *SN* strategy. The process is path dependent: the increase in x increases the wealth of ties on the Internet, thereby fostering the accumulation of online social capital and making social networking more and more attractive. At the end of the process, the economy is likely to converge to a state where all agents take care of their relationships both through face-to-face encounters and online networking, thereby expanding the stock of the social capital of the Internet at its highest possible level (β/γ). In principle, the analysis cannot provide a precise evaluation of the social desirability of this scenario. Both the steady states $(\beta/\gamma, 1)$ and (0,0) can be socially suboptimal solutions to the model, depending on the payoff structure.

In previous papers, we showed how the reduction in the time p devoted to social participation can trigger self-feeding processes leading to the progressive erosion of the stock of social capital. A decline in social participation may in fact reduce the productivity of the time spent on human interactions, thereby stimulating a process of substitution of relational goods with material ones, which will in turn cause a further decline in social participation (Antoci et al., 2011a,b). In these works, we analyzed a scenario in which time for social participation is an endogenous variable (i.e. it depends on agents' allocation choices) and social relationships can be developed just by means of face-to-face interaction. In the present paper, 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 shows that, under certain conditions, the substitution process causing the erosion of the stock of social capital can be impeded by the new forms of web-mediated communication. In this scenario, social interaction through the Internet can protect the relational sphere of individuals' lives from the pressure of time. The social capital of the Internet constitutes an infrastructure allowing social participation to overcome space and time constraints. The asynchronous interactions which take place on the Web can allow people to reconcile working activities and pervasive busyness with the need to take care of human relationships. We point out the interdependence between the rise in the pressure of time and the variation in the relative performance of the different modes of social participation. Agents can choose to develop their social participation through online networking as a defensive strategy against pervasive busyness. This result may look predictable, but the paper adds to the literature by providing a logical framework for analyzing the interdependence between increasing busyness, social participation and emerging phenomena such as online networking and, in general, Internet-mediated communication. The next step in our research programme will be the analysis of the agents' choice between the two possible strategies of social interaction within a new framework where the time p for social participation is no longer exogenously given.

Appendix A. [({Appendix})]

Proof of Proposition 1. $\dot{K}_N = 0$ holds along the straight line $x = (\gamma/\beta)K_N$ while $\dot{x} = 0$ in the states (K_N, x) satisfying the equation:

$$\Delta\Pi(K_N, x, p) := \Pi^{SN}(K_N, x, p) - \Pi^{FF}(x, p) = 0 \quad (8)$$

or in the states $(K_N, 0)$ and $(K_N, 1)$ satisfying respectively the conditions (see (2) and (3)):

$$\Pi^{SN}(K_N, 0, p) - \Pi^{FF}(0, p) \leq 0$$

$$\Pi^{SN}(K_N, 1, p) - \Pi^{FF}(1, p) \geq 0$$

So, under conditions (4) and (5), the states $(K_N, x) = (0, 0)$, $(\beta/\gamma, 1)$ are stationary states.

By the implicit function theorem we have that Eq. (8) defines a function $x = g(K_N)$ such that:

$$g'(K_N) = -\frac{(\partial\Delta\Pi)/(\partial K_N)}{(\partial\Delta\Pi)/(\partial x)} = -\frac{(\partial\Pi^{SN}/\partial K_N)}{(\partial\Pi^{SN}/\partial x) - (\partial\Pi^{FF}/\partial x)} < 0$$

Therefore the curves $x = (\gamma/\beta)K_N$ and $x = g(K_N)$ can intersect at most once. It is easy to check that, under the assumptions (4) and (5), these curves always admit an intersection point in the interior of the set S and, consequently, an interior stationary state (K_N^*, x^*) with $(\beta/\gamma) > K_N^* > 0$ and $1 > x^* > 0$ always exists.

Proof of Proposition 2. Notice that $\dot{K}_N > 0$ for $x > (\gamma/\beta)K_N$ and $\dot{K}_N < 0$ for $x < (\gamma/\beta)K_N$; furthermore, $\dot{x} > 0$ holds above the graph of the function $x = g(K_N)$ (see the Proof of Proposition 1) and $\dot{x} < 0$ below it. This implies that both the stationary states $(\beta/\gamma, 1)$ and (0,0) are locally attractive (see Fig. 1). The stability properties of the interior stationary state (K_N^*, x) can be easily checked by writing the Jacobian matrix of the dynamic system (6) and (7) evaluated at (K_N^*, x^*) (by assumption (b), $F_1(x,0) = 0$ always holds):

$$J(K_N^*, x^*) = \begin{pmatrix} -\gamma & \beta \\ F_2 \cdot \dfrac{\partial\Pi^{SN}}{\partial K_N} & F_2 \cdot \left(\dfrac{\partial\Pi^{SN}}{x} - \dfrac{\partial\Pi^{FF}}{\partial x}\right) \end{pmatrix}$$

This matrix has a strictly negative determinant and consequently the stationary state (K_N^*, x^*) is a hyperbolic saddle. Since the point (K_N^*, x^*) is a saddle, limit cycles cannot exist around it; therefore, by the Poincare–Bendixson Theorem, each trajectory approaches a stationary state.

Proof of Proposition 3. The basins of attraction of the stationary states (0,0) and $(\beta/\gamma, 1)$ are separated by the stable manifold of the stationary state (K_N^*, x^*) (see Fig. 1). This separatrix is the graph Ω

of a decreasing function of K_N with slope $(dx/dK_N) = (\dot{x}/\dot{K}_N) < 0$ if $K_N \neq 0$ (in particular, on the left of (K_N^*, x^*) we have $\dot{x} < 0$ and $\dot{K}_N > 0$, on the right $\dot{x} > 0$ and $\dot{K}_N < 0$). Let us consider two different values of p, p_1 and p_2, with $p_1 > p_2$, and indicate by $\Omega_{p=p_1}$ and $\Omega_{p=p_2}$ the separatrices corresponding, respectively, to the values $p = p_1$ and $p = p_2$.

Notice that, if p increases (ceteris paribus), the value of $\dot{x}$ decreases (i.e. $(\partial\dot{x}/\partial p) < 0$) by assumption (1) while that of $\dot{K}_N$ remains constant. It follows that, setting $p = p_2$, the locus $\Omega_{p=p_1}$ is crossed from the left to the right by the trajectories of the system (6) and (7) with $p = p_2$. This implies that the basin of attraction of $(\beta/\gamma, 1)$ is larger for $p = p_2$ than for $p = p_1$, that is, $\Omega_{p=p_2}$ lies on the left of $\Omega_{p=p_1}$ (see Fig. 2).

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