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Diffusion by imitation: The importance of targeting agents☆

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ABSTRACT

We study the optimal targeting strategy of a planner who seeks to maximize the diffusion of an action in a society where agents imitate successful past behavior of others. The agents face individual decision problems under uncertainty, make reversible adoption choices and interact locally, so that each agent affects only her neighbors. We find that the optimal targeting strategy depends on two parameters: (i) the likelihood of the action being more successful than its alternative and (ii) the planner's patience. More specifically, for an infinitely patient planner, the optimal strategy is to cluster all the targeted agents in one connected group when her preferred action has higher probability of being more successful than its alternative; whereas it is optimal spreading them across the population when this probability is lower. Interestingly, for an impatient planner the optimal targeting strategy is exactly the opposite.

1. Introduction

1.1. Motivation

Social interactions play a crucial role in the adoption of products, technologies and ideas (see Jackson, 2008; Rogers, 1995). Recent technological advances have made the collection and analysis of data related to the structure of interactions within societies possible, as well as the rules guiding their members' behavior. The appropriate use of this information can provide helpful tools for the effective propagation of certain objectives through targeted campaigns.

In this paper, we describe the optimal intervention of an interested party (from now on called *planner*) who seeks to maximize the diffusion of a given action in a society where agents imitate their neighbors' successful past behavior. This, for instance, could be a firm that produces a new product and wants to establish it in a new market. Optimal design of social influence campaigns is crucial, in particular when the planner has limited resources available.

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The focus of this paper is twofold. First, we highlight the importance of the distribution of targeted agents in the society. That is we examine whether and when the planner should cluster or spread the targeted agents. As it will become apparent, this turns out to be a crucial feature that has been overlooked until now. Second, we compare the optimal strategy of a shortsighted planner versus that of a farsighted one, which turns out to have very distinct characteristics. To the best of our knowledge this is the first paper to discuss thoroughly these two aspects.

More specifically, most of the existing literature on targeting has focused on the importance of central agents (see for instance Ballester et al., 2006; Banerjee et al., 2013). Having a high or a low number of connections (Galeotti and Goyal, 2009; Chatterjee and Dutta, 2011), or diffusing information to others who are poorly connected (Galeotti et al., 2011) are some usual characteristics of influential agents. The importance of these characteristics is beyond doubt. Nevertheless, we show that another factor with significant impact is whether the targeted agents are clustered together or they are spread across the society.

Furthermore, throughout our analysis we highlight the differences between optimal targeting strategies of a *patient planner* versus an *impatient* one, i.e. who cares about diffusion in the long run and short run respectively. It turns out that these two cases differ sharply and these differences persist independently of the parameters' values. This comparison is important in several scenarios, since different targeting strategies may be appropriate depending on the time horizon (Young, 2011).

Our model is quite general, however it would perhaps be more descriptive of a process related to the diffusion of agricultural innovations. Social learning, and imitation in particular, has a prevalent role in the diffusion of agricultural technologies.[1] The introduction of new technologies often occurs through formal private or public intervention and social interactions are vital for their subsequent diffusion (Rogers, 1995). Farmers face great uncertainty regarding their returns to the adoption of a new product or technology. The relative productivity of a new type of crops or the efficacy of a particular fertilizer may vary depending on the composition of soil or the area's climate. In addition to this, uncertainty of returns is further enhanced by unpredictable variations of weather conditions. These characteristics are often not transparent to the farmers beforehand, leading them to base their decisions on past experience, both their own and others'. As a result they often switch back and forth between adopting and abandoning a certain technology.[2]

Note that, the incentives of the planner may be different than those of the society, as for instance when the planner is a firm that wants to spread its own product. This means that the action of which diffusion is attempted to be maximized might be less effective than its alternative, with the relative efficacy often being known to the planner, but not to the agents. Propagation of suboptimal innovations is commonly observed in both agricultural technologies and other sectors.[3] However, it is hard to identify whether the propagators are aware of the lower relative efficacy of their product. A prevalent example, in which that is hard to argue, is the case of counterfeit drugs.[4] Their substance is similar to that of some original drug, but their relative efficacy is usually lower. This information is available to the producer, without necessarily being known to the consumers. This informational asymmetry has led in some cases to their widespread use, mainly in developing countries.[5]

In fact, in our model actions are differentiated based on their likelihood of being successful, rather than on their expected payoffs. Therefore it might be also the case that a planner wants to spread an action that is more risky than its alternative, but yields much higher payoffs when it is successful. In what follows, we analyze these cases separately, as they lead to different optimal targeting strategies.

There are several other examples that fit the general idea of the paper. For instance, a government that wishes to reduce criminal activity and is willing to sponsor a number of ex-criminals to change their lifestyle. Or else, a political or religious organization that wishes to propagate its ideology and locates a number of seeds in the society in order to spread the word to their neighborhood. As one can see, the problem of optimal social influence is directly applicable to a bunch of different environments and seemingly unrelated areas.

Undoubtedly, in order to obtain tractable and intuitive results we need to make a set of simplifying assumptions, which might reduce the applicability of our analysis in certain problems. Nevertheless, we provide a framework that can help us understand better which are the parameters that affect social influence crucially and we illustrate how beneficial the knowledge about society's structure may be for the efficient design of marketing and general social influence campaigns.

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[1] For a detailed discussion on the role of social learning in diffusion of agricultural technologies see Conley and Udry (2010), Duflo et al. (2011), Munshi (2004), Foster and Rosenzweig (1995) and references therein and for a more thorough exploration of the general dynamics of diffusion of innovations, including that related to agriculture, see Rogers (1995). For a recent field experiment that considers explicitly the role of social networks in technology adoption see Beaman et al. (2015).

[2] In different field experiments, Duflo et al. (2008) and Suri (2011) find that several farmers switch between using and not using fertilizer across periods.

[3] For agricultural technologies see Kelsey (2013) and Rogers (1995). Generally, there is a large literature discussing technological lock-in, where seemingly suboptimal technologies dominate entire sectors. Two examples that have triggered large academic interest are the technological lock-in in the use of light water reactors for generation of nuclear power (Cowan, 1990) and the use of QWERTY keyboard (see David, 1985 and subsequent criticisms by Liebowitz and Margolis (1990) and Hossain and Morgan (2009)). There is a wide range of explanations including the role of marketing and the importance of fads (Abrahamson, 1991) that lie beyond the scope of this paper.

[4] Counterfeit medicines may contain the same ingredients as the original product, but with incorrect concentration, or other similar but inactive ingredients. For a detailed discussion see Baratta et al. (2012) and references therein.

[5] Another important factor is that they tend to be cheaper, nevertheless their use is common even when the price difference between counterfeit and original product is small (see World Health Organization, 1999).