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Instability and network effects in innovative markets

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Abstract

We consider a network of interacting agents and we model the process of choice on the adoption of a given innovative product by means of statistical-mechanics tools. The modelization allows us to focus on the effects of direct interactions among agents in establishing the success or failure of the product itself. Mimicking real systems, the whole population is divided into two sub-communities called, respectively, Innovators and Followers, where the former are assumed to display more influence power. We study in detail and via numerical simulations on a random graph two different scenarios: *no-feedback* interaction, where innovators are cohesive and not sensitively affected by the remaining population, and *feedback* interaction, where the influence of followers on innovators is non negligible. The outcomes are markedly different: in the former case, which corresponds to the creation of a niche in the market, Innovators are able to drive and polarize the whole market. In the latter case the behavior of the market cannot be definitely predicted and become unstable. In both cases we highlight the emergence of collective phenomena and we show how the final outcome, in terms of the number of buyers, is affected by the concentration of innovators and by the interaction strengths among agents.

Keywords: Innovation diffusion; Agent-based; Collective phenomena; Innovators; Random network

1. Introduction

During the recent years, along with the growing diffusion of new methods of communication, social networking and people direct interactions have been increasingly analyzed by economic research, with new interesting results.

In particular, as stressed in [20], a new aspect which emerged is that the classical hypothesis of atomic agents has to be updated in order to allow for interactions among the individuals themselves. As emphasized in the classic study by Katz and Lazarsfeld [22], mass communication needs to rely on individuals to work because they do constitute the basis of the information network and the one-another-influence of decision-makers is a key process in information diffusion (see [26,13,15,6,8,30,4]). Additionally, what came out from their research (that has been drawn on and

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improved by Galeotti and many others, see [17,19,18,1]) is that the influence process on a community is largely determined by population heterogeneity [31,9]: information is mediated *by* mass media *to* opinion leaders (or Market Mavens) and *by* them *to* other different social classes, through inter- and intra-groups communication networks. In other words, we deal with a society stratification where each stratum has a different role, from collecting information to creating the network of relations the information will be spread through. Without losing much generality and for the sake of clarity, in most works on this topic, stratification has been simplified in just two classes, often called *Innovators*, i.e. the opinion leaders, and *Followers*, i.e. anyone else [7,12].

In this paper we want to highlight how such inhomogeneity and direct communication can affect the sales performance of a given innovative product. Hence, we consider a market composed by Innovators and Followers who can influence each other through direct (not market mediated) interactions [14]; as a result of such interaction they decide whether to buy or not to buy the product. In order to account for the different nature of agents we assume that the interaction strength, that is the influential power, depends on the agents involved. In particular, Innovators, being trend setters and displaying large cohesiveness, will be associated to a higher interaction strength. We also notice that, the degree of Innovators' leading role may depend on the nature of the innovative product considered. Indeed, we distinguish between two possible scenarios.

In the former, referred to as *no-feedback* scenario, the innovativeness of the product is sharp (e.g. determined by remarkable technological improvements) and easily identifiable by consumers; these points make the product non comparable with any other one available. Also, this kind of innovative product is typically characterized by a scarce reachability, due e.g. to high prices, limited number or poor spreading, in such a way that only a part of the population (i.e. Innovators) can afford to buy it and a market niche is established. Under these circumstances Innovators are very cohesive and not prone to abandon the novelty, being negligibly affected by the orientation of the remaining market. On the other hand, Followers, not having direct access to the product are significantly influenced by Innovators and, eventually, attracted by possible discounts, start to acquire it. As an example we can think of Apple Inc.: as they always try to create very original products, they establish brand new market segments. In this scenario we show that Innovators may act as a traditional advertisement, cost-free for the producer and whose effectiveness is directly related to the influence exerted; if the influence is strong enough, Innovators can lead most of market to follow their opinion.

In the other scenario, referred to as with *feedback*, the innovation introduced can be easily and quickly reproduced, in such a way that other brands can produce analogous items. Under these conditions everybody can try the novelty and mutually influence each other. Hence, in this case, the influence on Innovators due to Followers can be non negligible and the former, although being initially buyers, may change their mind. For example, this is the case of functional food products: some consumers do not believe that the innovation is really worth to be paid for and, moreover, the innovation can be so simple (e.g. adding vitamins) that after a short period all the main producers have adopted it. Our results suggest that such situations lead to an unpredictable market behavior, where reproducibility of product failure or success is unlikely, except for borderline cases.

In both scenarios, we observe the emergence of *collective phenomena*, leading to a global orientation of the market, which is typical of social networks. As a real world example look at Fig. 1, where the historical data about the diffusion of CD-ROM and VCR players are shown: for both products there is a certain point in time where the market abruptly polarizes and the share of households undergo a steep increase. This kind of behavior is indeed what is called a collective phenomenon and it is a well studied property of ferromagnetic systems, by which our model has been inspired. We will also show how the final outcome, in terms of the number of buyers, is affected by the concentration of innovators and by the interaction strengths among agents and we will highlight the existence of a critical region in our parameter space where the market is particularly sensitive to small changes and such information could be very useful for market forecasts.

The paper is organized as follows: in Sections 2 and 3 we introduce our model, its mathematical description and make some remarks on the idea of modeling social phenomena with statistical mechanics tools; in Section 4 we present our numerical results for the two scenarios and compare the related outcomes. The last section (Section 5) is devoted to conclusions and final remarks.

2. Model motivation

In this work we are considering a population where each individual has to decide between two alternatives and his/her behavior is explicitly affected by the previous decisions of his/her acquaintances.