Social Interactions *

José A. Scheinkman
Princeton University and NBER

Abstract

Social interactions refer to particular forms of externalities, in which the actions of a reference group affect an individual's preferences. In the presence of strategic complementarities, social interactions help reconcile the observation of large differences in outcomes in the absence of commensurate differences in fundamentals. I survey the theoretical literature and discuss different approaches to estimating social interactions.

Keywords: critical mass model, externalities, non-market interactions, random fields, social multiplier, strategic complementarities.

1 Introduction

Social interactions refer to particular forms of externalities, in which the actions of a reference group affect an individual's preferences. The reference group depends on the context and is typically an individual's family, neighbors, friends or peers. Social interactions are sometimes called non-market interactions to emphasize the fact that these interactions are not regulated by the price mechanism.

Veblen's [1934] analysis of conspicuous consumption that is consumption that signals wealth, is perhaps the first contribution to the economic literature on social interactions. Duesenberry [1949] and Leibenstein [1950] are also among the earliest contributors. Although Veblen's Theory of the Leisure Class has had a remarkable impact in the social sciences, Schelling's

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[1971,1972] pioneering formal analysis of the influence of social groups in behavior was particularly important for the later developments in economics.

Models of social interactions seem particularly adapt to solve a pervasive problem in the social sciences, namely the observation of large differences in outcomes in the absence of commensurate differences in fundamentals. Many models of social interactions exhibit *strategic complementarities*, which occur when the marginal utility to one person of undertaking an action is increasing with the average amount of the action taken by his peers. Consequently, a change in fundamentals has a direct effect on behavior and an indirect effect of the same sign. Each person's actions change not only because of the direct change in fundamentals, but also because of the change in the behavior of their peers. The result of all these indirect effects is the *social multiplier*. When this social multiplier is large, we expect to see the large variation of aggregate endogenous variables relative to the variability of fundamentals, that seem to characterize phenomena as diverse as stock market crashes, religious differences, and differences in crime rates. In fact, if social interactions are large enough, multiple equilibria can occur - that is one may observe different outcomes from exactly the same fundamentals. The existence of multiple equilibria also helps us to understand high levels of variance of aggregates.

Social interactions models have implications for the sorting of people and activities across space. As Schelling [1971] demonstrated, when individuals can choose locations, the presence of these interactions may result on segregation across space, even in situations where the typical individual would be content to live in an integrated neighborhood, provided his group does not form too small a minority. Cities exist because of agglomeration economies which are likely to come from non-market complementarities. In dynamic settings, social interactions can produce s-shaped curves which help to explain the observed time series patterns of phenomena as disparate as telephone adoption and women in the workplace.

Closely related topics include social learning, where agents learn from observing choices by other agents (e.g. Arthur [1989], Bickhchandani, Hirshleifer and Welch [1992]), and local interaction games (e.g. Ellison[1993], Morris [2000]).

2 Schelling's critical mass model

In chapter 3 of his 1978 book, Schelling discusses a *critical mass model* where he supposes that there is an activity which some individuals will always take, others will only take it if a high enough fraction of the population is engaged in the action, and still others may never undertake. Formally, agents are parameterized by an $x \in [0, 1]$, and can choose between taking an action or not. The gain in utility for an agent of taking the action is given by $u(x, t)$, where t is the fraction of the population engaging in the action. Schelling assumed that $u(x, t)$ decreases with x, that is agents can be inversely ordered by their gains from undertaking the action. He also assumed that $u(x, t)$ increases with t, that is the gain is larger if a larger fraction of the population is engaged in the action. This assumption is exactly what was later named "strategic complementarity." Each agent x takes t as given and chooses to take the action if and only if $u(x, t) \geq 0$. An equilibrium is a fraction t^* such that $u(t^*, t^*) = 0$. Clearly for such a t^* every agent $x \leq t^*$ will undertake the action while, if $x > t^*$, agent x would refrain. Schelling constructs a numerical example where multiple equilibria arise and notices that even when uniqueness prevails such models display a "multiplier effect." In his example, the presence of a smaller number of individuals that would undertake the activity unconditionally would have a more than proportionate effect in the equilibrium level of the activity. Gravonetter [1978] proposes a very similar model to analyze riots and other collective actions. He notes that as parameter changes some equilibria may disappear leading to drastic changes in the equilibrium outcomes.

Versions of the critical mass model described in Schelling [1978] were later used to study a myriad of economic questions, often with a more detailed microeconomic foundation to justify strategic complementarities. Examples include income inequality (Loury [1977] and Durlauf [1996]), social customs (Akerlof [1980]), the big-push in industrialization (Murphy, Shleifer and Vishny [1989]), crime (Sah [1991]), education (Benabou [1993], savings and consumption norms (Lindbeck [1997]), the transmission of culture (Bisin and Verdier [2000]), and the timing of desertion by soldiers (De Paula [2005].) A continuous action version of the same model, where an agent's utility depends on the average action of the population, was used by Cooper and John [1988] to model macroeconomic coordination failures. Much of this work has ignored market responses to the presence of social interactions. Among the exceptions are Becker and Murphy [2000], who produced a systematic analysis of the effect of prices on market behavior when social interactions are present, and Pesendorfer [1995] who examined how a monopolist would exploit the presence of non-market interactions.

3 Models inspired in statistical physics

Schelling's [1971] paper describes a model where individuals occupied discrete points on the line or plane and interacted locally. However, most of the developments that followed used the simpler critical mass model. Follmer [1974] was the first to use explicitly a random field model, also known as an interactive particle system, imported from statistical physics to model social interactions. In these models one typically postulates individual's interdependence and analyzes the equilibrium behavior that emerges. Typical questions concern the existence and multiplicity of equilibria that are consistent with the postulated individual behavior, and the sensitivity to parameters of these equilibria. Follmer modelled an economy in which the preferences of an individual depended on the preference of his peers and showed that randomness in individual preferences may affect the aggregate, even as the number of agents grows to infinity - a failure of the law of large numbers. Blume [1993] and Brock [1993] recognized the connection between models of discrete choice with interaction effects and some random field models.

Glaeser, Sacerdote and Scheinkman [1996] observed that crime rates across large American cities seem to vary too much to be explained by the usual socio-economic variables. They constructed a theoretical model connecting the structure of social interactions among individuals with the variation of aggregate behavior across space, providing a framework for investigating the importance of social interactions. They showed that a simple model of local interactions inspired in the voter model of the literature on interacting particle systems[1] was able to generate the large observed variance across aggregates, from small amounts of variability in the fundamentals. A simple, one-sided, version of their model works as follows. Individuals occupy discrete points on a circle and choose among two actions $\{0, 1\}$. With probability π, the individual chooses action 1 with probability p and action 0 with probability $1 - p$. With probability $(1 - \pi)$ he imitates his predecessor's action. The parameter $(1 - \pi)$ can be thought of a measure of the intensity

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[1] *e.g.* Ligget [1985]

of social interactions. In a population of n individuals if we write a^i for the action of agent i then

$$\frac{1}{\sqrt{n}}\sum_{i=1}^{n}(a^i - p) \to N\left(0, \frac{2-\pi}{\pi}p(1-p)\right).$$

Although the limit average action is always p, the (limit) variance of the normalized average action across groups is a function of π. As π converges to zero, this variance gets arbitrarily large. Social interactions increase the variance of crime rate across population groups. In a similar vein, Topa [2001] examines the spatial distribution of unemployment with the aid of contact processes[2], another class of random field models, and shows that social interactions help explain the variation in unemployment rates among Chicago census tracts.

Brock and Durlauf [2001] develop a model that is very much in the spirit of Schelling's critical mass framework. Individuals choose between two actions and the utility of taking an action for each individual depends on a baseline utility that is common across individuals, on a idiosyncratic preference parameter, and on the distance between his action and the average expected action in the population. By making specific assumptions on the probability distribution of the idiosyncratic preferences, Brock and Durlauf obtain a joint probability measure over choices that is related to that of the mean-field version of the Curie-Weiss model of statistical mechanics. They then show that the model may have one or three equilibria, depending on the values of some parameters. Multiple equilibria are more likely to appear when the baseline utility of the two actions is not very different or when the desire for conformity is strong. Durlauf [1997] and Ioannides [1997] and [to appear] consider generalizations of the Brock-Durlauf framework with a richer interaction structure that accommodates local interactions. Horst and Scheinkman [to appear], who do not use explicitly the language of random fields, also consider infinite systems with arbitrary interaction structures.

Most of this literature is static, but dynamics models, usually involving myopic agents, are developed, for example, by Blume[1993], Blume and Durlauf [1999], Brock and Durlauf [2001], and Young [1993] and [1998] who is especially interested in the evolution of social norms and customs.

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[2] *e.g.* Ligget [1985]

4 The social multiplier

The *social multiplier* measures the ratio of the effect on the average action caused by a change in a parameter to the effect on the average action that would occur if individual agents ignored the change in actions of their peers. This social multiplier can also be thought of as a ratio $\frac{\Delta_P}{\Delta_I}$ where Δ_I is the average response of an individual action to an exogenous parameter (that affects only that person) and Δ_P is the (per capita) response of the peer group to a change in the same parameter that affects the entire peer group. Unless an equilibrium selection mechanism is present, the social multiplier is only well defined if the equilibrium average action is unique, but models that exhibit large social multipliers can explain large differences in outcomes across populations with small differences in exogenous variables. If agents have idiosyncratic random preferences this same multiplier amplifies the differences in realizations of these preferences across samples. In models with continuous actions but otherwise fairly general interaction structures Glaeser and Scheinkman [2003] and Horst and Scheinkman [to appear] show that *Moderate Social Interactions*, a condition that limits the effect of the actions by peers on the optimal choice of an individual, is sufficient for uniqueness of equilibrium. They also show that if, in addition, strategic complementarities are present then the social multiplier exceeds one. Typically, the forces that lead to multiple equilibrium also lead to large social multipliers. For instance in the Brock-Durlauf [2001] model, in the region where uniqueness prevails, the social multiplier is bigger when the desire to conform is stronger and when the fraction of agents that are close to being indifferent between the two possible actions is larger. (see Glaeser and Scheinkman [2003]).

5 Choice of peer group

In several models (*e.g* Gabszewicz and Thisse [1996], Benabou [1993], Glaeser, Sacerdote and Scheinkman [1996] or Mobius [1999]) the peer group that concerns an agent is formed by geographical neighbors. Mobius [1999] shows that, in a context that generalizes Schelling's [1972] tipping model, the persistence of segregation depends on the particular form of the near-neighbor relationship.

Kirman [1983], Kirman, Oddou and Weber [1986], and Ioannides [1990] use random graph theory to treat the peer group relationship as random.

This approach is particularly useful in deriving properties of the probable peer groups as a function of the original probability of connections. Another literature deals with individual incentives for the formation of networks (*e.g.* Boorman [1975], Jackson and Wolinsky [1996], Bala and Goyal [2000].)[3] Benabou [1993] and Glaeser and Scheinkman [2001] use Tiebout's equilibrium approach (see e.g. Bewley [1981]) to model peer group choice.

6 Empirical issues

There are several statistical problems that arise in estimating social interactions effects. It is often difficult for a researcher to identify correctly the peer groups. Another problem is that, ideally, one should distinguish between three effects in understanding group behavior: correlation of individual characteristics, influences of group characteristics on individuals, and the influence of group behavior on individual behavior (Manski [1993]) Although the last two effects could both be merged into a social interactions effect, the correlation across individual error terms could remain a problem.

This problem does not arise in randomized experiments that allocate persons into different groups. Katz, Kling and Liebman [2001] and Ludwig, Hirschfeld and Duncan [2001] use data generated by the Moving to Opportunity experiment to provide evidence for the existence of neighborhood spillovers on juvenile crime. Sacerdote [2001] exploits variation in peer groups generated by the random assignment of freshman roommates at Dartmouth and finds evidence of peer effects on academic effort, GPA, and fraternity membership.

In the absence of randomized experiments Case and Katz [1991] used peer group background characteristics as instruments for peer group outcomes, which in certain cases yields valid estimates of social interactions. They found some evidence that peer behavior influences self-reported juvenile crime. However, as Manski [1993] stresses in the presence of correlations among unobservables, which is particularly likely to arise with sorting, the instrumental variables estimator may overstate social interactions.

Brock and Durlauf [2001] discuss structural identification for their model. In Brock and Durlauf [2000] they provide estimators for the parameters of the model and account for the endogeneity of peer groups. This structural ap-

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[3] A related problem is the formation of coalition in games *e.g.* Myerson [1991].

proach leads to a natural behavioral interpretation of the parameters, but it requires individual level observations and it may suffer from misspecification.

A less structural approach, that was proposed by Glaeser, Sacerdote and Scheinkman [1996], is to use the variances of group average outcomes to identify social interactions. Using this methodology they found evidence that social interactions can help explain the large differences in community crime rates. This approach was formalized further by Graham [2004]. Another possibility is to use the logic of the multiplier. The relationship between exogenous variables and outcomes for individuals is compared with the relationship between exogenous variables and outcomes for groups. The ratio is a measure of the size of social interactions. Glaeser, Sacerdote and Scheinkman [2003] apply this method and find evidence of interactions in social group membership in the Dartmouth roommates data and on crime, and of human capital spillovers at the a state or Public Use Microsample Area (PUMA) level. Yet another alternative is to identify the presence of interactions based on spatial clustering in the behavioral data. (see Topa [2001] and Conley and Topa [2002]). Finally, results in De Paula [2005] suggest that dynamic models might be easier to identify.

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